SOURCEBOOK OF

MODERN TECHNOLOGY FOR HOSPITALS AND HEALTH CARE

1989

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MODERN TECHNOLOGY FOR HOSPITALS AND HEALTH CARE

Edited by:
Dr. Ashok Sahni
Professor and
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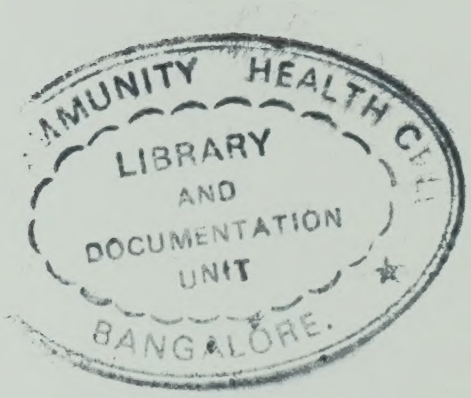

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PREFACE

During the last four decades, since the attainment of independence in 1947, notable progress has been made in all spheres of developmental activities - social, economic, industrial, and political. In the health field, considerable progress has been achieved in the promotion of health status of the people. Smallpox has been eliminated; plague is no longer a problem; mortality rate per thousand population has been reduced from 27.4 to 14.8 and the life expectancy at birth has increased from 32.7 to nearly 58. We have over 700,000 doctors covering all systems of medicine; approximately 600,000 beds in 8000 hospitals, 14,500 primary health centres, and 1,10,000 subcentres. Significant indigenous capacity has been established for the production of drugs and pharmaceuticals, vaccines, sera, hospital equipments, etc.

Nearly 500 colleges and schools produce annually over 50,000 medical and paramedical personnel. To meet with the health care needs of approximately 1,680 million people in India by 2020 AD, the manpower and institutional infra-structure will increase four to five times.

In the last two decades, tremendous advances have also been made in medical technologies, diagnosis and treatment all over the world, including in India, which have improved the health and quality of life of people in India. Health professionals and administrators in India-in public and private sectors - are greatly interested in the effective utilisation of modern technology in providing efficient, qualitative and cost-effective health care in India. As India moves towards the 21st century, rapid development in production and utilization of modern technology in the medical and health field will take place. The professionals and administrators will be charged with the responsibility of effective and appropriate adoption and utilization of modern technologies. For this however, they need to be informed and educated about the availability and utilization of these technologies.

Keeping in view ISHA's objective of development of health professionals and systems towards effective health care in India, and realizing the above needs, we are happy to bring out this SOURCEBOOK OF MODERN TECHNOLOGY FOR HOSPITALS AND HEALTH CARE, to provide comprehensive and authoritative information regarding current clinical, analytical, diagnostic and treatment aspects of medicine. In addition to its medical core of about 30 papers covering all major aspects of medicine and surgery,the SOURCEBOOK covers supportive and administrative services relevant to medical and health care, besides providing listings of reputed manufacturers and suppliers of products and services for the various specialities.

We are thankful to the noted experts and professionals in India who warmly responded to our request to write special chapters for the SOURCEBOOK. We are also thankful to editors of HOSPIMEDICA, LAB MEDICA, and MEDICAL FOCUS and through them to the various international experts who encouraged us in the preparation of this SOURCEBOOK.

We are grateful to Mr. R. Chandrasekar, Medical Devices Consultant, Bangalore, for all the advice given in the planning of this book. We are particularly grateful to Mr. Keneth Menzies and Mr. Perry Menzies, proprietors of Adverto Advertising Agency, for their creative guidance, and assistance given in the promotion of the SOURCEBOOK to manufacturers and suppliers of modern technology.

I am extremely grateful to my colleague, Dr. Sudha Xirasagar, for providing excellent research and editorial assistance. I am equally grateful to our administrative staff - Miss Nirmala Naidu, Miss Nandini Upadhya, Mr V. Manoj, Miss Shashi Kala, Miss Shubalakshmi and Mr. Narendra for their excellent secretarial assistance. I am also grateful to Mr. M. S. Nagendra, Proprietor, Yem Yes Printers, for planning the physical aspects of the SOURCEBOOK and for quality printing under tight schedule.

I am especially grateful to the leaders and executives of organizations engaged in the manufacture and distribution of modern technology and equipment for choosing the SOURCEBOOK as a medium to share information with the health professionals and administrators to plan and develop modern health systems so as to provide quality health care.

Ashok Sahni

FOREWORD

In the domain of modern technological support to hospitals and primary health care, for the improvement of quality of health care, information technology is one of the most universally needed and utilized. With the astounding explosion of new innovations in this area as this book details, the issues relating to appropriateness assume an ever-increasing importance. The World Health Organization's goal of "Health For All", with its stated strategy of Primary Health Care (PHC) warrants even more, the appropriate use of the potentials that information and communication technologies have to offer in order to ensure equal access to quality health care service, within the various general and specialized care areas.

The WHO Programme on Quality of Care and Technologies is stressing the importance of information technology in all aspects of care, hospital care, primary health care and health education.

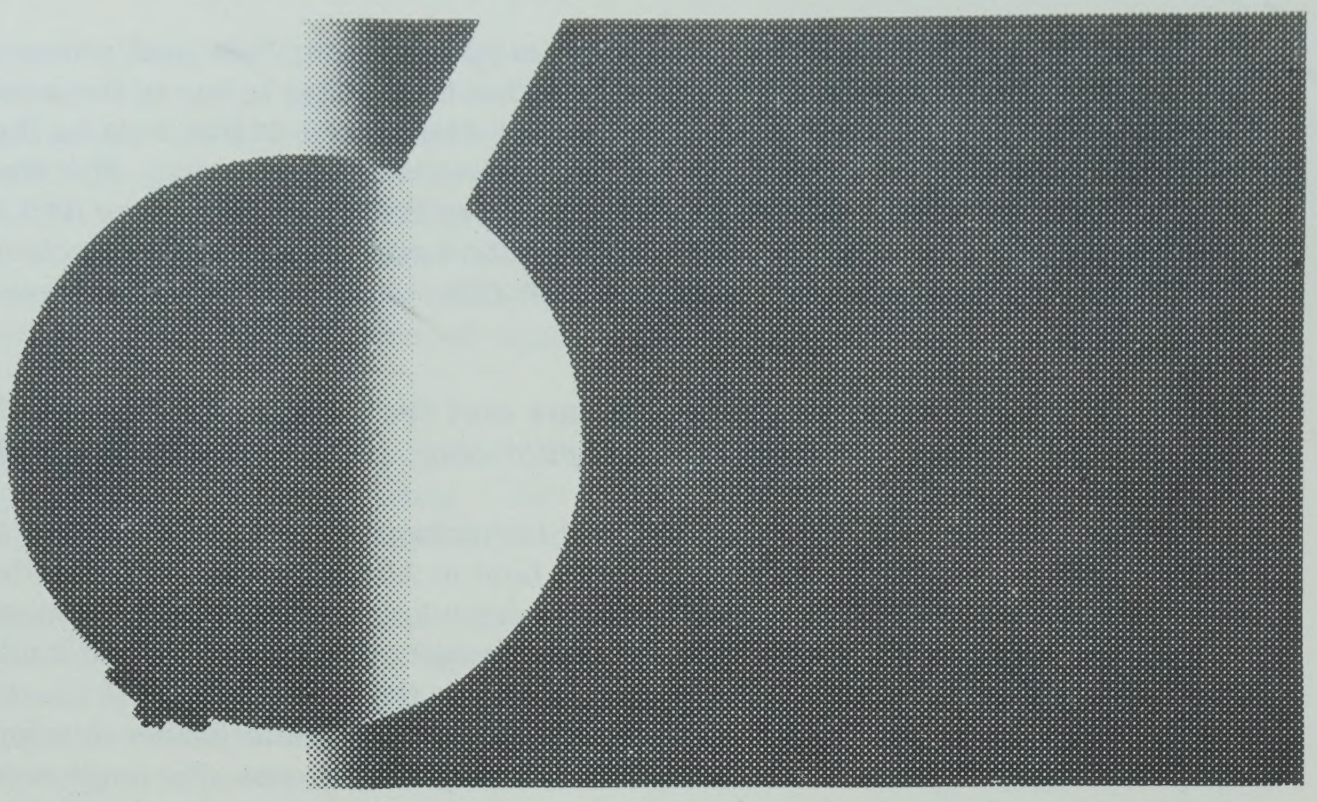
A clarification of the term "appropriate technology" is perhaps in order. The report of the International Conference on Primary Health Care, held in Alma Ata (6 - 12 September 1978) defines "technology" as an association of systems, methods, techniques, drugs and equipment together with the people using them. The same report explains appropriateness as being scientifically sound and at the same time, acceptable to the people who apply it and to those for whom it is used, in keeping with the local culture, relevant to local needs, capable of being adapted and further developed if needed, simple and easy to use, and possible to manufacture locally at low cost. Our emphasis is not just on the use of appropriate technologies but also on appropriate use of technolgies. While the meaning of appropriateness may be interpreted differently by various authors, and criteria have been identified to help us measure this entity, we would like to point out that in most cases the appropriateness of a technology to a given situation is determined by the way it is used. Thus, advances in both diagnostic and therapeutic applications of new and existing technologies require testing, using common protocols, to allow for comparison of results in various settings. The standards for comparison should be based on medical and health outcomes, including patient acceptability and satisfaction as well as use of resources and functionability. The use of appropriate information systems, to collect, analyze and feed back data on these measures to the relevant parties is for ensuring and developing quality of health care services.

Irrespective of the stage of development that a country is in, every health care system needs an effective and efficient information system. Every possible technological help that can provide this support and ensure a good mechanism for monitoring and evaluation of the health care services and their impact, is absolutely crucial. BUT, by simply placing the technology at the disposal of health care providers, one cannot expect this to happen as is true for all medical and health technologies. An APPROPRIATE implementation of the technology is the key. In this context, appropriateness assumes a connotation of being need-based as well. Therefore, data that give care providers a clearer picture of the cost and health outcomes of the population they serve, based on their interventions and practices, must be generated and used. Even though functions such as diagnostic assistance, treatment assistance are important, it must be stressed that the main goal of an information system is to improve the efficiency of management and to provide a monitoring and evaluation system to ensure quality of care.

With this brief foreword, I wish to thank the members of the Indian Society of Health Administrators who have recognized the need to assess technologies and other experts who have contributed valuable suggestions and articles to the contents of this book. We do hope that this book is found to be useful by health care planners and managers who are in need of appropriate medical and health technolgies. The challenge is to ensure their appropriateness for the improvement of health care quality and outcomes.

Kirsten Staehr Johansen, MD., DDS
Chief
WHO Programme on
Quality of Care and Technologies

Those split-second, life and death decisions...



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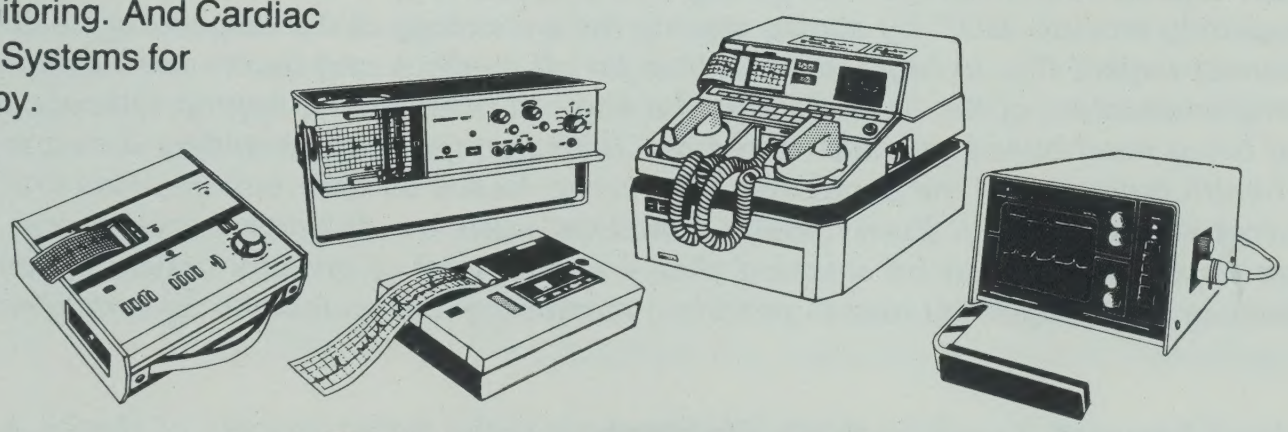

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Editor's Note

1. As a result of the progress in medical sciences, application of modern technology in diagnostic and therapeutic modalities, and the benefits of modern technology to the common man, the quality of life has improved, the longevity has increased, mortality rates decreased, and critical cases saved. This has resulted in abundance of happiness and welfare of the society.

2. These recent advances in diagnostic and therapeutic modalities, in almost all fields of medicine,have largely been due to the breakthroughs in medical imaging technology. Since the discovery of X-rays by William Roetgen, which was the first landmark in medical imaging, safer, non-ionizing radiation techniques have been discovered with less harmful or no side-effects and better accuracy of diagnosis.

3. Magnetic Resonance Imaging (MRI) images tissues with great accuracy without exposing the patient or the radiologist to the risk of ionizing radiation. It is being used extensively in all fields of medicine and surgery singly, or in combination with other techniques to enhance its usefulness.

4. The development of nuclear medicine (radionuclide imaging) has wide applications to detect tissues/areas with abnormal metabolism, localize cancers, early detection of myocardial and cerebral ischaemia, and many others.

5. Medical imaging techniques are now being combined with interventional techniques for therapeutic purposes to relieve stenosis or obstruction in biliary drainage, nephrostomies, stent placement, deep-seated stone removal, abscesses, vascular dilatation (of coronary and peripheral vessel stenosis) - the balloon angioplasties, etc. The result is a vastly improved patient outcome (especially in coronary balloon angioplasty) with reduced morbidity and mortality, following a safe, relatively non-invasive, non-surgical procedure instead of a major surgical procedure.

6. Ultrasound technique, alone or combined with Doppler effect is being widely applied in virtually all fields of medicine. Being a relatively cheap investigation with low initial investment costs, widely applicable and most of all, no risk of ionizing radiation, it may emerge next only to X-ray examination as the most widespread diagnostic tool in both developed as well as developing countries. It is widely applied in obstetrics where risk to foetus is the prime consideration in applying any diagnostic tool.

7. Computed Tomography, though it still remains an X-ray examination, provides for superior and localised tissue images. The most valuable and extensive application of CT has been in neurology where accurate localization and understanding the nature of lesions makes all the difference to therapeutic decisions and patient outcome. Newer three dimentional CTs are already guiding surgeons for highly accurate micro-surgery.

8. Cardiology continues to be preoccupied with ischaemic heart disease because of the sheer predominance of IHD patients in cardiology practice. As expected, the applications of recently discovered imaging techniques, evolution and modification of known techniques and procedures, have concentrated on improving patient outcome and survival rates in IHD patients. Prominent among these are MRI, computerized tomography and radionuclide studies to assess anatomical and physiological parameters of heart disease, not only for prognostic purpose but also to accurately select patients for preventive interventions like bypass surgery, balloon angioplasty of localized stenosis of coronary blood vessels, or cardiac transplantation. However, the most widely used equipment in cardiology will continue to be electrocardiography and echocardiography which still hold the top position. Apart from cost factors, there are several other technical and operational factors which render them more widely applicable, as discussed in the chapter on the interaction of echocardiography with recent non-invasive imaging techniques in diagnosis. Other diagnostic modifications of known techniques include ultrasound, cardiac catherization, coronary angioscopy, endomyocardial biopsy via transvenous cardiac bioptome. Most of these techniques utilize imaging modalities like fibre-optics, fluoroscopy, etc.,

9. In therapy, in addition to newer highly cardio-selective drugs, advancements include implantable and external use of artificial pacemakers. Pacemakers are continuously undergoing

refinement and sophistication for better effectiveness with minimal complications. A recent addition is the automatic implantable cardioverter defibrillator (AICD) which is expected to prolong the life of survivors of cardiac arrest and enable them to lead a useful, working life. Interventional catheterization, i.e., combination of diagnostic with therapeutic procedure in one, has been found useful for balloon angioplasty to prevent myocardial infarction or relieve ischaemic symptoms in selected cases.

10. In the area of neurology, one of the most widely available and long-used equipment remains the electro-encephalograph which has maximally aided neurologists and psychiatrists. It has undergone considerable modification since the early models with increase in diagnostic accuracy and better patient management. Computerised somato-sensory evoked potentials which provide for recording activity of functionally selective areas of the brain—visually evoked and brainstem evoked potentials, have extended the diagnostic usefulness of the basic principle of EEG.

11. Among imaging techniques in neurology, computerized tomography has proved to be the one of the most useful. MRI adds to imaging accuracy especially with the superior ability to delineate lesions at the base of the brain. Cerebral angiography has undergone further modification with digital computer processing and is used to study disorders of cerebral blood flow. Advances in immunology have added to diagnostic and prognostic capability for the neurophysician. Advances in genetics and molecular biology of the inherited CNS disorders and prevent tragic occurences of many degenerative CNA diseases.

12. In obstetric practice, ultrasound techniques with or without application of the doppler effect, has overtaken most other technologies because of its non-ionizing nature, relative safety for the foetus, and relative cheapness. Another visualization technique extensively applied in gynaecology is fibreoptic technology used in hysteroscopy, laparoscopy and colposcopy. These diagnostic techniques have been modified into interventional technologies by suitable addition of facilities, to carry out selective ablation and other surgeries with minimal tissue disturbance and patient morbidity. Many of the modern techniques reduce the need for major operative interventions, reduce patient stay in hospital, morbidity and mortality, and improve accuracy of surgery.

13. In cardiothoracic surgery in addition to the obvious role of MRI and computed tomography, modified versions of fibreoptic instruments and several new innovations have been introduced for non-invasive imaging of the oesophagus, lung function, etc. Amongst the imaging technologies fibre-optics remains the prominently useful technology in cardiothoracic diagnosis and management.

14. Continued modifications and newer discoveries of materials for vascular grafts along with computer-guided microsurgery form, the frontiers of development of vascular surgery. Techniques like laser surgery are still under evaluation as to their use in cancer surgery.

15. *In the area of orthopaedics, the importance of X-ray examination cannot be undermined in terms of its usefulness, cost, out-reach in all parts of the world, and numbers of people whose suffering it helps to relieve.* The newer imaging techniques, MRI and computed tomography, have added to accuracy of diagnosis and patient relief in orthopaedic practice. Together with artherscopically aided joint surgery, improved vascular surgery techniques, and advancement in microsurgery, lives and limbs are better conserved and in better functional condition. The computer has rendered orthopaedicians more capable of restoring the handicapped patient back to normal functional life through its applications in biomechanical gait analysis and gait reconstruction, joint reconstruction, custom-made orthopaedic implants, etc.,

16. In urology practice, fibreoptics continues to rule high as a means of the least invasive or even non-invasive surgical procedures. The latest addition to manage renal stones without surgery in selected cases, the extra corporeal shock wave lithotripsy is currently very expensive.

17. Advances have been made in renal transplantation, management of male infertility and impotence through advancement of microvascular surgery, amongst others. Other imaging systems like CT scans, MRI and ultrasonography have specific applications in urology.

18. In the area of hospital and health care planning and management a new emerging area which merits attention because of increasing incidence of trauma in urban life, is the planning and management of accident and emergency services which has been extensively discussed in the relevant article.

19. Very complex computers are now an integral part of medical technology, whether it is MRI, ultrasound, CT or any other. While the computer as a part of hospital equipment is well accepted, as a part of hospital and health care information management, it has yet to gain wide acceptance among doctors and administrations, especially in developing countries. Computers prove invaluable in hospital administration, administrative information transfer and update between departments, and time management of doctors and nurses in a hospital. In the public health field, with the advent of personal computers, the critical problem of timely field data collection and surveillance to monitor disease and health status of communities for efficient health care delivery, now has the potential of being solved. More tricky, in terms of acceptance by the medical and paramedical professionals, are the issues of monitoring quality of hospital and health care through computerized surveillance systems, and hospital data analysis to monitor, for example, indicators like mean lengths of hospital stay, medical and nursing care plans, drug treatments of standard disease groups, etc.

20. Nevertheless in terms of the well accepted application of computers in hospital administration, it has resulted in more efficient utilization of resources, better patient management, lower medical care costs for both hospitals and patients, better bills realization by the hospital, prevention of unnecessary repeat tests, etc. This has been, by and large the experience of most hospitals where computerization was implemented effectively.

21. In the control of communicable diseases, today, the problem remains, chiefly one of transfer of known simple technology and operational problems of its application on a large scale in developing countries. Nevertheless some diagnostic problems continue to dog communicable disease control programmes. The front line research in this field is concentrated on early detection of leprosy and tuberculosis to check their spread, through immunological tests.

22. With the worldwide tremendous interest and funding for research and advancement of basic sciences, discoveries and technologies that emerge rapidly find their applications in industry, agriculture, information management, and concomitantly in medical care, too. Once applied, a technology undergoes modification, refinement and further advancement to satisfy the requirement of the medical care specialists. Keeping in view the immense costs of this process and the equipment, caution and evaluation should be exercised so that, we do not pursue the application of technology for its own sake with minimal or no benefit to patient outcome, perhaps sometimes to chiefly satisfy the physicians' curiosity. The benefits of allocation of scarce health resources (whether public or private funds) for technology oriented equipment should be carefully weighed against the benefits of allocation for (possibly simpler but) more basic health services with wider out-reach, more so, in developing countries where these areas compete with each other for the available scarce resources.

23. In short, the place that each innovative technology should occupy in the country's overall health care system, should result from a carefully weighted decision, rather than from a fascination with complex gadgets.

Dr Ashok Sahni
Professor and
Hony Executive Director.

November 14, 1989

Cardiology

1. Modern Technology In Cardiology - Present And Future Perspectives of Application And Utilization

Dr. A. Garg & Prof. H. S. Wasir**

I General

Advances in technology are transforming our lives. New techniques can revolutionise treatment, reduce costs dramatically and hold out new promise for saving human lives. These thoughts have been the guiding force for the present day emphasis on use of technology in management of cardiovascular disorders and continued research for application of technological advances in cardiological practice. The application of modern technology as discussed below has remarkably improved both diagnostic evaluation and therapeutic management of patients with cardiovascular disorders.

II Technology Application In Diagnostic Evaluation Of Cardiovascular Disorders.

Technology application in non-invasive and invasive diagnostic methods has perfected the art of cardiovascular diagnosis. This has facilitated use of various therapeutic modalities including complicated cardiac surgery. The technology application, however, as discussed below, is extensive and varied and requires adequate insight into various methods for their effective use.

A. Electrocardiography

One of the earliest applications of technology was in obtaining a record of electrical activity of heart from body surface which came to be known as electrocardiography[1] (ECG). ECG has since then evolved into an extremely useful clinical laboratory tool. The resting 12-lead ECG has been used to identify chamber hypertrophy, tissue ischaemia and necrosis, haemodynamic and metabolic changes. ECG also serves as a gold standard for the diagnosis of cardiac arrhythmias. Since physical exertion typically provokes attacks of angina pectoris, a technique was developed to record changes in ECG appearing on exercise, also known as stress or *exercise electrocardiography*[2]. In the past, Master's step box was used for objective assessment of exercise performed, and the ECG records were made after the exercise was over. However to improve sensitivity, the cycle ergometer and treadmill have proved more practical, where the recordings are done through and post-exercise. The present day exercise is performed on a treadmill or a cycle ergometer with computerised ECG analysis to avoid any observer bias. *Ambulatory electrocardiographic monitoring* came as the next major advance in technique of electrocardiography[3]. It is particularly useful in arrhythmias which are infrequent, for symptom correlation, for evaluation of symptoms in patient's own domestic and working environment. Ambulatory ECG monitoring can be either on continuous recorders (Holter monitoring) or ECG monitoring when patients senses symptoms which are transmitted telephonically to an ECG receiver *(trans-telephonic monitoring)*. The latter technique is more useful in very infrequent arrhythmias. A more recent use of ambulatory ECG monitoring is in detection of painless episodes or silent ischaemia by ST segment shift. In the past there were technical limitations for satisfactorily detecting ST segment shift such as low frequency response recorders and use of a single lead system. Frequency modulated recordings have enhanced the reliability of ST pattern recording and interpretation during ambulatory ECG monitoring. The new technique of QRS signal averaging allows detection of signals that are otherwise masked by random noise.[4] Ventricular late potentials, His-bundle activation and sinus node potentials have been recorded from body surface. In recent years ventricular late potentials have been found useful in evaluation of patients with ventricular tachyarrhythmias. Esophageal electrocardiography adds a new dimension to electrocardiographic techniques. Recording atrial activity from the esophagus is simple, non-invasive and an ef-

* *Department of Cardiology, Cardiothoracic Centre, All India Institute of Medical Sciences, New Delhi - 110 029*

fective method. The esophageal pill electrode is easily swallowed and well tolerated. Esophageal ECG is likely to find greater use in evaluation of cardiac arrhythmias[5].

B. Echocardiography

Echocardiography which uses ultrasound in the millions of cycles per second range has become a well established non-invasive and reliable method of cardiac imaging. The detection of returning or echoed ultrasound waves helps in detailing the position and movement of cardiac acoustic interfaces. The initial echocardiographic examination consisted of M-mode examination[6], where the ultrasound beam is aimed in one direction and therefore depicts a single dimension of target structure, which is a continuous graph of the depth of the structure with respect to time. It provides ideal means of following motion of cardiac structures and assessment of size of various cardiac chambers. The advent of two dimensional (2-D) echocardiography was a major development in the field of cardiac ultrasound.[7] The two dimensional beam sweeps in an arc to yield a panoramic view of the heart that results in cross-sectional images that are anatomically recognisable. It is an excellent method to study cardiac anatomy in infinite number of cross-sectional images and finds its use in congenital, valvular, myocardial and peri-cardial disorders. The addition of Doppler device was the next significant milestone in the evolution of cardiac ultrasound. The Doppler device detects the change in frequency between the emitted and the returning ultrasound signals, also known as Doppler shift.[8] The Doppler shift is determined by the direction and velocity of blood flow. The velocity of blood flow is increased and the flow is turbulent across obstructive segments. This forms the basis of detection and quantitation of valvular stenosis. The abnormally directed jets suggest presence of valvular regurgitation or intracardiac shunts. While pulsed wave Doppler is useful in detecting abnormal signals at various depths in cardiac image, the continuous wave Doppler is useful in quantifying high velocity of jets. A more recent advance in echocardiography is Colour Flow Mapping or *'Colour Doppler Echocardiography'*.[9] It is useful in quick detection of abnormally directed signals and quantitation of valvular regurgitation. The latest addition to echocardiographic techniques is the use of esophagus as a window for echocardiographic evaluation, also known as *esophageal echocardiograph.*[10] It has found special use in evaluation of patients with poor echogenicity, left atrial thrombi, mitral prosthesis, dissection of aorta and evaluation of cardiac hemodynamics during surgery.

C. Radionuclide Studies

Radionuclide methods provide a safe, non-invasive and quantitative approach to assessing the variety of cardiac functions. They can be applied during exercise and other physiological and pharmacological interventions.[11] The commonly used equilibrium blood pool scintigraphy requires in vivo or in vitro labelling of red blood cells by ^{99}technitium. A gamma-camera or a non-imaging probe is then used to evaluate left and right ventricular ejection fraction and indices of regional ventricular performance at rest and on exercise. First pass ^{99}Technitium studies are useful in shunt detection and quantitation.

^{201}Thallium perfusion imaging is useful in detection of reversible cardiac ischemia in combination with exercise and/or intravenous dipyridamole. Infarct- avid imaging is useful in diagnosis of myocardial infarction. The various radiopharmaceuticals used for this purpose are ^{99}Technitium pyrophosphate, radiolabelled antibodies against cardiac myosin and ^{111}Indium- labelled white blood cells. The most recent advance in nuclear cardiology is Positron-emission tomography[12]. Mismatch of myocardial metabolism (increased ^{18}Flouro -2- deoxyglucose uptake) and perfusion (reduced^{3}Nitrogen - ammonia uptake) indicates presence of myocardial ischemia. Positron-emission tomography has provided insights in the understanding of pathophysiology of reversible myocardial ischemic states showing impaired contractile function such as hibernating and stunned myocardium.. In future, positron emission tomography may provide true volume images and thus provide more accurate estimates of the extent of normal, reversible and irreversibly injured myocardium.

D. Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) has two important attributes that make it advantageous for cardiac diagnosis. Firstly, a high natural contrast exists between circulating blood pool and the cardiovascular structures. Secondly, a wide range of soft tissue contrast provides potential for myocardial tissue characteristation. MRI has been used in diagnosis of congenital heart disease, cardiomyopathy, pericardial disorders, dissection of thoracic aorta and diagnosis of myocardial infarction.[13] Myocardial tissue char-

acterisation depends upon estimation of signal intensity and relaxation times. This helps in early diagnosis of acute myocardial infarction and cardiac transplant rejection.

E. Computerised Tomography (CT)

Standard CT scanning is particularly useful for evaluation of pericardial disorders, coronary artery bypass grafts and thoracic aortic dissection.[14] However, for evaluation of cardiac function and precise cardiac anatomy, millisecond CT scanners or ultrafast CT scanners are necessary.

F. Cardiac Catheterisation

One of the biggest advances in cardiology of this century is the establishment of cardiac catheterisation as a safe and reliable technique to evaluate cardiac functional status. Cardiac catheterisation has also served as a gold standard for evaluation of various non-invasive diagnostic methods. Cardiac catheterisation is an invasive procedure performed under fluoroscopic guidance and requires intracardiac manipulation of catheters to record pressures and oximetry data from various cardiac chambers, from which data regarding cardiac function, systemic and pulmonary flows, and vascular resistances are estimated. Cardiac catheterisation has found its use in pre-operative evaluation of cardiovascular disorders, especially in combination with angiocardiography.[16] Angiocardiography is a technique where a radio-opaque contrast medium is injected in a cardiac chamber or vessel and its intracardiac flow pattern is studied, and recorded on photographic film, to delineate cardiac and vascular anatomy.[17] Angio-cardiography has been useful in evaluation of coronary artery disease and valvular and congenital heart disease. Digital arteriograms obtained by *Digital subtraction angiography* facilitate post acquisition image processing and analysis, such as magnification, edge enhancement, quantitative arteriography and estimation of coronary flow reserve.[18] The amount of contrast media required is also much less, assuring greater safety. With the advent of newer imaging techniques especially Doppler echocardiography, the role of diagnostic catheterisation is narrowing down. However, another emerging use of cardiac catheterisation is invasive cardiac monitoring in critically sick patients using balloon tipped catheters. This provides bedside estimation of cardiac output, filling pressures and vascular resistances, parameters which help in monitoring and guiding therapy. *Cardiac electrophysiologic studies* can also be performed by mounting electrodes on the tips of cardiac catheters to record intracardiac electrical activity and to stimulate heart at selected sites. These techniques are of great value in elucidating the mechanism and treating a variety of cardiac arrhythmias.[19]

G. Endomyocardial Biopsy

Non-operative cardiac biopsy is now possible using a transvenous cardiac bioptome placed against the endocardium of the interventricular septum under fluoroscopic guidance. The technique is useful in diagnosis of myocarditis, infiltrative cardiomyopathies and cardiac transplant rejection.[20]

H. Coronary Angioscopy

Pre-operative coronary angioscopy has been performed in patients undergoing coronary bypass surgery and has shed light on the pathogenesis of unstable angina.[21] A new low profile , highly flexible fiber-optic angioscopy catheter is being tested at some centres for safety and efficacy of the device. Angioscope may alter treatment plans according to underlying pathologic anatomy.

III. Technology Applications in Therapy of Cardiovascular Disorders

Technological advances and their application in basic sciences such as biochemistry, pharmacology, genetic engineering, immunology and others have led to the emergence of highly potent and effective pharmacotherapeutic agents such as calcium channel blockers, newer anti-arrhythmic agents, thrombolytic agents and immunosuppressants. Other areas of technology application for treatment of cardiovascular disorders include *implantable* and *external* use of *cardiac pacemakers* and *defibrillators*. However the centerpiece of technological applications in therapy of cardiovascular disorders is interventional catheterisation.

A. Interventional Catheterisation

Until 10 years ago, cardiac catheterisation was predominantly a diagnostic tool. The technique of balloon dilatation was developed by Andreas Gruentzig in 1974, as a treatment for peripheral atherosclerotic stenosis, ushering in the use of balloon dilation of stenotic cardiac and vascular lesions, Balloon dilation of coronary

atherosclerotic stenosis began in 1977. During the early years percutaneous transluminal coronary angioplasty (PTCA) was limited only to patients with proximal, discrete, subtotal stenosis of a single coronary artery and primary success rate was only 60 per cent.[22] In contrast, coronary angioplasty is now being applied routinely to patients with more complex coronary anatomic situations with a higher success rate.[23] This remarkable improvement in balloon angioplasty has come through rapid advances in balloon catheter, guide wire and guiding catheter technology. The present day guiding catheters have high torque allowing greater control, have flexible, soft and atraumatic tip which avoids any vessel damage, have extra-large internal diameters which facilitate double balloon technique through one guiding catheter and permits easier contrast injection. The guide wires have also improved in trackability, torque control and radiographic visibility. The refinements in balloon dilatation catheter design has led to lower profiles, improved trackability and flexibility. The balloon material has also changed from initial polyvinyl chloride to polyethylene terephthalate (PET). This polymer permits high balloon inflation pressure (upto 15 atmospheres) and yet has very low compliance (stretch)- less than 15% at maximal pressure. This is all the more remarkable in view of the extreme thinness of PET. These capabilities of PET balloon permit its use in most hard and tight lesions. Th new ultra-low profile coronary angioplasty system is the balloon on a wire device, in which a PET balloon is directly positioned over the tip of guidewire thus achieving a very low profile.[24] Thus with each coronary balloon angioplasty technologic advance, the indications are widening, the success rates are improving, and incidence of acute complications is falling. Balloon dilation of cardiac valves has also been achieved. Initially single balloon was used to dilate stenotic valves; however, presently two-balloon systems are more commonly used. Two-balloon systems achieve larger valve area, reduce risk of systemic hypotension and milking of balloons during inflation.[25] The immediate results of balloon dilatation of all cardiac valves are good.[26] Balloon dilation of other congenital lesions such as coarctation of aorta, peripheral pulmonary artery stenosis, subaortic membrane[27] and others have also been reported.

Although balloon technology remains the cornerstone of interventional vascular therapy, newer technologies are emerging to provide the interventionist with a "bag of tools" rather than a single method. *Laser energy* which destroys tissue by vaporisation has been successfully used to recanalise totally occluded femoropopliteal arteries.[28] In coronary angioplasty, laser technology may be particularly useful in treatment of chronic total occlusions and diffuse atherosclerotic segments. It may also bring down the restenosis rate because laser vaporisation leaves smoother surface. At present laser recanalisation of coronary arteries is limited by inflexible nature of laser device. Currently catheters with improved flexibility, trackability, low profile and a central lumen design are being investigated and appear promising. Another mechanical approach to angioplasty besides balloon technology is the transluminal extraction catheter.[29] It consists of a motorised rotating stainless steel element equipped with conical cutting head.

The cutting head is mounted on a flexible torque tube incorporating a vaccum system that allows retrieval of the excised material. The device is wire guided. It has been successfully employed in peripheral vascular disease, with low restenosis rates because it leaves a smoother surface. It use in coronary angioplasty singly and in combination with balloon angioplasty is being evaluated. Only a partial success has been achieved in non-surgical management of non-stenotic lesions compared with remarkable success in non-surgical management of stenotic lesions. Catheter closure of intracardiac defects remains highly experimental and will require considerable advances before it becomes accepted therapy. Rashkind Double Umbrella device has been used to close patent ductus arteriosus, atrial septal defects, and ventricular septal defects.[30] Coil embolisation to occlude aorto-pulmonary collaterals, arterio-venous malformations, Blalock-Taussing shunts and patent ductus arteriosis, has been found safe and effective.[31] With further improvement in technology it is expected that non-surgical management of non-stenotic lesions will become a more practical alternative. Another interesting area where catheter-directed therapy has been employed is *electrical ablation* through cardiac catheter for tachyarrthmias.[32] The technique has been effectively used for ventricular and supraventricular arrhythmias.

B. Artificial Cardiac Pacemakers

Entering its third decade, cardiac pacing continues to be a rapidly advancing and ever-changing technology. The value of pacing in the treatment of a variety of brady and tachyarrhyth-

mias cannot be challenged. Recent advances in pacemaker technology include new electrode designs and lead insulators, miniature electronic circuitry, long lived power sources, multi-programmability, dual chamber pacing systems and the most recent concept of rate-responsive pacing. The dual chamber pacing re-establishes atrio-ventricular synchrony and this improves resting cardiac output by 15 to 20 percent, by maintaining atrial kick.[33] This has tremendous beneficial effect in patients with severe left ventricular systolic and diastolic dysfunction. However in a patient with normal ventricular function, the other more important factor that physiologically aids the cardiac output is rate responsiveness or the ability to increase heart rate with increasing demands. *Sensor technology* is the application of sensors which detect various electrocardiographic, hemodynamic, metabolic and other changes occuring on exercise, and use it for rate-responsive function of cardiac pacemakers. The various sensors available sense the vibrations of muscle or physical activity, the QT interval, blood pH, central body temperature, mixed venous oxygen saturation, minute ventilation, rise of stroke volume and right ventricular systolic pressure on physical exercise.[34]

C. Cardioverters/Defibrillators

External direct current cardioversion has been a safe, reliable and rapid treatment of re-entrant arrhythmias both as an elective and an emergency measure. Application of high energy electrical shock results in simultaneous depolarisation of all cardiac tissue, with initial recovery of the dominant pacemaker, normally the sinus node. The effectiveness of this technique in therapy of malignant ventricular arrhythmias depends on immediate availability of trained personnel and equipment. These two stumbling blocks in conventional out of hospital resuscitation have been eliminated by development of *automatic implantable cardioverter defibrillator* (AICD).[35] The AICD is a self contained diagnostic-therapeutic system; it continously monitors the heart, identifies ventricular fibrillation or tachycardia and then delivers corrective discharges to restore normal rhythm. AICD is implanted by a surgical technique requiring thoracotomy or through subxiphoid approach. The clinical experience suggests that AICD may emerge as the gold standard in management of survivors of out-of-hospital cardiac arrest.

Lastly, although the technological advances have provided us with a broad range of diagnostic and therapeutic techniques to help patients with cardiovascular disorders in prolonging and improving quality of life, the fruits of medical technology raise important economic and social issues. At the present time, efforts to improve medical care through advanced technology are rarely circumscribed by cost considerations. Yet, we cannot ignore the fact that the cost of medical technology is already enormous and growing steadily. All this does put a burden on the patient and his family. The rapid developments in medical technology should however be used with great caution. While taking care of the heart employing the most sophisticated gadgets, the physician should continue to take care of the person as an individual; his psyche is as important as his heart. With the gains in the practice of science of medicine, the practice of art of medicine should not be lost.

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2. *Interaction of Echocardiography With Recent Noninvasive Cardiovascular Imaging Modalities*

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Echocardiography (echo), in the past 10 years has accelerated as a principal noninvasive cardiovascular imaging modality. Although appearing much more recently than echocardiography, cardiac applications of computed tomography (CT) and magnetic resonance imaging (MRI) have developed rapidly, and these newer methods have evolved into independent imaging techniques with unique diagnostic capabilities. Clinically, echocardiography is usually the first examination used when heart disease is suspected: therefore, it is helpful to explore the interactions of echocardiography with the emerging modalities of cardiac CT and MRI. This paper will examine the overlapping and complementary capabilities of these techniques, in addition to interactions of a more competitive nature.

Conventional cardiovascular CT

The first CT scanners were very limited for cardiac purposes because they were designed initially to image only nonmoving structures-specifically the brain, spine, and abdomen. Nevertheless, despite limitations including a long exposure time of 2-5 seconds, single slice capability, and a repetition rate of at most 10-14 scans per series (caused by heat load restrictions on the x-ray tube), interestingly, useful cardiac CT applications became possible. [1-19] Unfortunately, relatively few centers are experienced with cardiac CT imaging, although nearly every hospital has at least one whole body CT scanner. These early experiences brought two advantages; first, it defines the role of CT for cardiac diagnosis and second, it provided the impetus for the development of a practical ultrafast cardiac CT scanner, which will be described later in this article.

Basic CT protocols used during a typical cardiac study have been described previously in the literature. However, some important aspects of the technique are worth emphasizing. The location of the scans (which are usually 0.5 or 1cm thick) is defined precisely by the operator and is registrated in terms of the CT table position. This is a major advantage over all other techniques, including MRI and echocardiography, where reproduction of the same imaging plane is operator rather than computer-dependent. This geometric precision eliminates at least one potentially significant source of error in quantitating cardiac dimensions and functions. CT is superior to X-ray fluoroscopy and film for locating and identifying calcification even in small structures like the coronary arteries. CT can depict all four cardiac chambers and separate all arterial from venous structures, and also, displays the myocardial wall extraordinarily clearly even without ECG gating (an option available on some conventional CT units).

Echocardiography frequently detects aneurysms of the abdominal and thoracic aorta, most often as incidental findings. The proximal portions of the ascending aorta lie close to the echo transducer and are, therefore, most easily imaged. Echo can image only one segment of the aorta at a time, however, making it difficult to echocardiographically assess the true extent of an aneurysm. Although echo has been described as a reliable technique for evaluating aneurysms of the descending thoracic aorta,[20] adequate assessment of the transverse and descending thoracic aorta is frequently difficult, particularly in the emphysematous or obese patient. On the other hand, CT is capable of clearly demonstrating aneurysms of the thoracic and abdominal aorta, also clearly defining intraluminal pathology (e.g. mural thrombus). CT is also useful in detecting localized effects of aneurysms on contiguous structures.[1] Most importantly, CT provides a noninvasive, sensitive, and reproducible means

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of sequential assessment of an aneurysm's contour and luminal caliber.

Aortic dissection is frequently a life threatening medical emergency, requiring quick and dependable assessment. Echocardiography is a useful noninvasive tool in the diagnosis of ascending aortic dissections[21]. Echo will clearly detect aortic root dilatation in proximal dissection. Also, a combination of 2D, Doppler, and M-mode formats can be utilized to assess the status of the aortic valve and document the presence of concomitant aortic insufficiency.[2,22] However, echocardiographic images of the ascending, transverse, and descending aorta are often poorly resolved and unreliable, particularly in the setting of the critical care unit. In comparison, CT has the capability of imaging the entire aorta, in addition to defining not only the site but the extent of the dissection. Occasionally, CT without contrast detects displacement of the calcified intima into the aortic lumen by a false channel. CT with contrast, particularly in the dynamic scanning mode (i.e., a rapid series of sequential scans taken at the same anatomic level used in combination with the intravenous injection of contrast material), frequently defines the intimal flap, allowing differentiation of the true and false lumena[3-5]. Also periaortic extravasation and hematoma can be visualized. In addition, dynamic CT scanning offers the advantage of demonstrating differential flow in the true and false lumena; when the false lumen is obliterated by thrombus, no enhancement is seen. These same phenomena can also be seen with Doppler echocardiography,[23] but its reliability in this setting is questionable. Both echocardiography and conventional CT are capable of visualizing pericardial fluid, which in the setting of aortic dissection, is associated with a poor prognosis. [23] Additionally, in the presence of a pericardial effusion, echo is the imaging method of choice to demonstrate dynamic right atrial and right ventricular collapse compatible with tamponade physiology.[24]

Recent advancements in the field of transesophageal echocardiography propose that this new form of echocardiography could become a significant diagnostic tool in the initial diagnosis of distal aortic dissection.[25,26] With further refinements and patient experience of technique, this modality should become commonly available.

Echocardiography is the established, superior technique in the evaluation of pericardial disease. It is an easily performed, sensitive, noninvasive, and relatively inexpensive method for detecting pericardial effusions and demonstrating the presence or absence of tamponade physiology. In situations where echocardiographic imaging is not technically adequate or feasible, CT is easily capable of demonstrating pericardial fluid.[6] Additionally, the density (in Hounsfield units) of the fluid on CT scans may help to clarify the nature of the effusion; high density effusions may possible represent either hemopericardium[27-29] or exudate[7] and low density effusions may represent either chyle or transudate.[8] Traditionally, the diagnosis of pericardial thickening is one of the limitations of echocardiography because of the highly reflective nature of both the normal and the thickened pericardium. CT provides a more accurate and reproducible means of assessing pericardial thickness. The normal pericardium is approximately 1-2 mm thick, with a pericardial thickness of 4 mm or more, and is seen in the presence of pericardial constriction.[9] This ability of CT to differentiate normal from thickened pericardium may prove to be of substantial use of distinguishing restrictive cardiomyopathy from constrictive pericarditis. [6, 18]

Calcification of the parietal and visceral pericardium illustrates the residual effect of pericardial inflammation and is strong evidence for the present of chronic pericardial disease. Although calcium clearly reflects ultrasound, its echocardiographic signal is not sufficiently different from normal or fibrotic pericardium to enable the distinction to readily be made. However, radiographically, calcification is easily identified, but the three-dimensional (3-D) tomographic capability of CT is superior to conventional fluoroscopy and film for the evaluation of calcification. When combined with contrast enhancement CT is especially useful either in the diagnosis or exclusion of constrictive pericarditis.[6,18]

Occasionally, masses abutting the pericardium are detected on echocardiographic exams . However, just as frequently, large masses near the heart border are not seen because they lie outside the routine field of view. When either clinical suspicion or echocardiography raises the question of a mediastinal or pericardial mass, CT not only can define the extent of cardiac involvement but also identifies involvement of other structures in the chest. Contrast-enhanced CT is also used to delineate the myocardial and intrapericardial extension of malignant disease. However, although tomography is able to outline the true boundaries of tumor involvement, it cannot show the motion of intracardiac portions of

tumors during the cardiac cycle as echocardiography can.[30]

Other masses near the heart that can create diagnostic dilemmas are pericardial cysts. Both echo and CT can detect presence of these fluid-filled sacs, as well as verify their cystic nature. Because of its excellent spatial resolution, CT is useful in defining the size and geometry of the cyst, as well as identifying its attachments to cardiac or mediastinal structures. Echocardiography, in terms of mobile cardiac tumors, remains the imaging method of choice in most instances. CT, however, has reportedly been used with some success in the diagnosis of atrial myxomas.[10, 11]

Left ventricular (LV) thrombus formation is a frequent and major complication of myocardial infarction.[31] Apical thrombi frequently occur in the setting of left anterior descending artery occlusion, with resultant extensive anterior wall myocardial infarction and apical aneurysm formation. Echocardiography frequently definitely identifies apical thrombi because of the setting and their distinct echocardiographic appearance. However, uncertaintly can occur with echo imaging because at times it is difficult to visualize the entire aneurysmal LV apex. In these examples, CT provides the advantage of clearly defining endocardial surfaces and aneurysmal areas, in addition to delineating differing tissue thickness.[12-14] Contrast enhanced CT has recently been shown to provide sensitivity similar to that of echo in detecting LV thrombi[15] and is a reliable imaging alternative in those patients with equivocal echo result[1] or in whom visualization of the LV apex by echo is technically inadequate or difficult.

In the past, left atrial thrombi have presented a diagnostic challenge. Echocardiography has exhibited poor sensitivity in the detection of thrombi in this chamber. However, in a recent study, contrast-enhanced CT showed 100% sensitivity in identifying the presence of left atrial thrombus as compared to an echo sensitivity of only 60%.[14] Also, thrombi in the left atrial (LA) appendage are well illustrated by CT. If further studies show the same excellent results, contrast-enhanced CT may become a preferred procedure in the diagnosis of left atrial thrombi.

Contrast-enhanced CT has shown some value in the diagnosis of pulmonary intravascular pathology in the setting of chronic thromboembolic pulmonary hypertension.[16] 2-D echocardiography has also demonstrated the capability of identifying pulmonary artery dilatation and proximal pulmonary artery thrombosis in the setting of pulmonary hypertension and thromboembolic disease.[17]

Ultrafast (Cine) CT techniques

Echocardiography is a well-established modality in the assessment of valvular morphology and dysfunction, regional left ventricular function, and cardiac chamber dimensions. Also, the capability of accurately determining ejection fraction, left ventricular volumes, and mass from the echocardiographic image has been demonstrated.[32] The reproducibility of this methodology has been verified recently in our laboratory.[33] The aforementioned techniques of quantitative echocardiography are primarily limited by the adequacy of the echocardiographic images, which is a combined function of acquisition technique, operator skill, and the availability of an echocardiographic window. If any of these components is lacking, the accuracy and reproducibility of echo quantitation in hindered.

Cine CT is a new modality that is currently developing into a powerful new cardiologic tool. The weaknesses of conventional CT in the field of cardiac diagnosis has led to the development of a high-speed cardiac scanner that is based upon the use of an electron beam, which is magnetically, rather than mechanically, deflected.[19,34] Eight different anatomic levels can be scanned simultaneously using ultrafast CT, with a scanning exposure time of 50 msec and a maximum repetition rate of 17 frames/sec at each level. This imaging technique shows promise not only as a complementary method of obtaining information similar to that mentioned above, but can also give additional, unique diagnostic data.

Three different modes of operation are routinely incorporated into each procedure: a continuous or cine mode, a volume mode, and a flow or triggered mode. In the flow mode of image acquisition, parameters including regional tissue flow, cardiac output, and vascular blood flow can be determined.[35] Recently, quantitation of regional myocardial perfusion by cine-CT in an animal model has been shown to correlate well with regional myocardial flow as assessed by microspheres.[36] Because measurement of relative myocardial perfusion is possible, cine-CT could potentially be used to assess coronary artery reserve if the examination were to be performed in combination with some form of dynamic exercise.

Similarly, cine-CT has the potential to demonstrate the absence of blood flow in an area of infarcted myocardium. A further potential use of the flow mode of acquisition is the measurement of shunt fractions in intracardiac shunts, which has been successfully demonstrated in animal models.[37]

Dynamic cardiac motion is displayed in the cine mode, allowing assessment of segmental wall motion, dynamic right and left ventricular function, and valve motion. Detection of left ventricular wall motion abnormalities by cine-CT compares favorably to cineangiography.[34] Also, the high resolution of cine-CT sharply delineates epicardial and endocardial surfaces, allowing quantitation of dynamic myocardial thickness, as well as cavity dimensions. This data can then be used to accurately calculate left-ventricular ejection fraction.[19,39] Also, the ability to confidently assess dynamic left ventricular wall thickness may prove beneficial in the diagnosis of ischemic heart disease because the correlation between segmental wall thickening abnormalities and the presence of myocardial ishcemia has been well established.[38.40.41]

Currently, cine-CT is being evaluated for a variety of other diagnostic studies. Its 3-D imaging capability makes it ideally suited for the evaluation of aortic and pericardial abnormalities, as well as providing an enhanced look at cardiac anatomy (including LV aneurysms and associated thrombi. Recently, cine-CT has proved to be a valuable tool in the diagnosis of congenital heart disease, providing detailed imaging of cardiac defects, in addition to an analysis of cardiac function (including ventricular volumes, regurgitant volumes, ejection fractions, and shunt ratios).[42] Left ventricular mass has been accurately quantitated in animal models using cine-CT.[43] In several centers that have recently acquired cine-CT scanners, various validation studies of chamber and wall dimensions in man are currently being performed[19] The tomographic advantages of cine-CT are important, especially in conditions in which hypertrophy is asymmetric, as in some types of cardiomyopathies.

MRI techniques

MRI is a powerful, rapidly emerging technique in the diagnosis of cardiovascular disorders. Through the use of low strength dynamic magnetic fields, high-strength static magnetic fields, and radio-frequency pulses, tomographic images of the body with high soft tissue contrast are generated.[44] Similar to echocardiography, it is completely noninvasive, requiring no contrast media for anatomic visualization. However, unlike echo, routine MR image acquisition and reconstruction is a somewhat lengthy process, requiring the patient to remain motionless in an isolated environment for usually a minimum of 15-30 minutes. MRI is uniquely suited to cardiovascular imaging because flowing blood generates little or no MRI signal, producing spontaneous contrast between the vascular spaces, blood pool, and the cardiac structures.[45] Also, the high soft-tissue contrast clearly demarcates pericardium, myocardium, and pericardial fat.[46-48] Initially, cardiac motion in nongated MR images produces substantial image degradation: however, gating techniques have been devised that has considerably improved the quality of MR images of the heart.[49]

Because of its ability to sharply delineate epicardial and endocardial surfaces, MRI can identify regions of segmental wall thinning indicative of prior myocardial infarction. [46-50] Furthermore, areas of severe wall thinning and bulging in patients with LV aneurysms have been identified with MRI, as have mural thrombi also seen by echo and CT. [45] MR imaging of acute myocardial infarctions (with involved myocardium appearing as regions of increased signal intensity relative to normal myocardium) is being accomplished in both animal models[51] and in human subjects.[52]

Precise determination of left ventricular mass by MRI has been reported in several animal models.[53.54] Gated MRI is also being used to define the severity, presence, and distribution of abnormal wall thickness in patients with hypertrophic cardiomyopathy. [50.55] In these individuals, the myocardial wall is clearly defined, allowing accurate measurement of differential wall thickness. Results acquired in these situations with MRI is comparable to those obtained echocardiographically. In patients with congestive cardiomyopathy, MRI has clearly depicted dilatation of the left ventricle in conjunction with either normal or mildly reduced wall thickness.[50] One should remember that although MRI has shown utility in acquiring the information mentioned, the same data (in most circumstances) can be obtained echocardiographically.

Abnormalities of the thoracic aorta, including true and false aneurysms,[56] periaortic abscess,[57] and coarctation[58] have been visualized with MRI. In a recent series, MRI was successfully used in the initial evaluation and subsequent post-treat-

ment follow-up of 10 patients with coarctation.[59] MRI has been particularly effective in the diagnosis of aortic dissection.[56,60,61] The ability of MRI to demonstrate an intimal flap has been verified in several studies, [60,62] as has the capability of defining the true and false lumena[2,62]. MRI is especially valuable in the evaluation of the descending aorta, also providing anatomic information regarding the branch vessels.[2] The limitations of echo in this area are considerable and MRI has clearly established its role as a diagnostic modality in this condition. Its noninvasive nature may displace CT in this application in the near future.

Gated-MRI directly visualizes the pericardium. which in the nondiseased state appears as a thin, low-intensity band surrounding the entire heart or, most often, the anterior portion of the heart.[63] Pericardial thickening is seen in patients with suspected constrictive pericarditis.[64] Low-signal intensity is also in the purely fibrous or extensively calcified pericardium of chronic constrictive pericarditis, whereas acutely or subacutely inflamed pericardium displays high signal intensity.[63-65]

Both loculated and generalized pericardial effusions have been imaged by MRI. Again, noninflammatory effusions were found to have low-signal intensity, whereas inflammatory effusions exhibited high signal intensity.[63] Although MRI has the ability to detect loculated effusions (which are sometimes poorly defined by echo), as well as to characterize the nature of the fluid to some degree, echocardiography remains the initial procedure of choice for evaluation of pericardial effusion. Characterization of the fluid, however (e.g. blood vs purulent exudate), is an inherent capability of MRI.

In the assessment of paracardiac and cardiac masses, MRI has several advantages over echo because MRI is capable of clearly imaging noncardiac structures, has a large field of view, and clearly defines the limits of pericardium[50] and myocardium[50]. Because the pericardial boundary is well defined, MRI can determine whether or not paracardiac masses have entered the pericardium and/or the pericardial space. Gated-MRI is superior in evaluating masses in the vicinity of the heart, as well as for demonstrating vascular compromise by tumor compression or invasion.[66] Intracardiac masses (e.g., myxomas) are clearly defined by MRI[50]. Especially in either the emphysematous or obese patients in whom echocardiographic imaging of small intracardiac masses can be particularly difficult, MRI may provide a way to readily demonstrate such pathology. Echo is also helpful in the diagnosis of endomyocardial fibrosis[67]-, MRI is used to obtain equivalent and complementary visualization of ventricular cavity involvement.

The initial diagnostic procedure of choice in adults and children with congenital cardiac anomalies is still echocardiography. However, MRI clearly shows intricate congenital anomalies including double-outlet right ventricle, single atrioventricular valve, uncorrected L-transportation, atrioventricular septal defect (ASD), hypoplastic ventricle, single ventricle, and surgical shunt repairs.[68-70] Venous abnormalities including persistent left superior vena cava and anomalous pulmonary venous connections have also been identified by MRI[50]. MRI has great potential as a diagnostic tool in detection of atrial and ventricular septal defects; in one series, MRI was 100% sensitive in the detection of five ASDs and 90% sensitive in the detection of 11 ventricular septal defects (VSDs)[68] However, in a recent study is was deduced that echo is probably superior to MRI for the detection of ASDs and both modalities exhibit similar sensitivities and specificities in the detection of VSDs[71]

Conclusion

MRI, echocardiography, and CT are noninvasive imaging modalities with unique capabilities and limitations in the delineation of cardiovascular anatomy and pathology. Echo remains the most inexpensive, portable, and rapid of the three techniques, with a multiplicity of clinically proven uses. However, echocardiographic imaging is, to some degree, limited by a relatively narrow field of view, the need for operator expertise (or lack of it), the necessity for an echocardiographic window unimpeded by bone or lung tissue, and at times, less than adequate image resolution with modern technology. CT is not dependent on operator skill or hampered by body habitus; however, the majority of CT examinations require the use of a contrast agent that exposes the patient to potential toxic reactions, as well as the possibility of contrast-mediated nephrotoxicity. This consideration is especially relevant in the patients with either atherosclerotic or hypertensive cardiovascular disease who may have marginal renal reserve (either subclinially or clinically) and be especially prone to postcontrast renal failure. Also, the patient undergoing a CT exam is often critically ill but has to be placed in a remote environment without direct monitoring capability. MRI, like echo, is truly noninvasive

because no contrast medium is needed for visualization of cardiovascular structures. Similar to CT, however, the patient undergoing an MRI exam is required to lie in a remote, confined area for a period of time. Unlike echo or CT, patients on life support systems, with cardiac pacemakers, or intracerebral surgical clips cannot be imaged by MRI. However, it should be pointed out that both cardiac CT and MRI are still very young in their development. Further refinements of both techniques will widen their cardiac applications and enhance their use as cardiac imaging modalities. Recent advances in MRI technology appear to have greatly increased temporal resolution and reduced image acquisition time. In conjunction with the superior spatial resolution that the inherent high soft tissue contrast of MRI provides, these innovative techniques promise to produce high resolution, anatomically detailed, dynamic cardiac images.

In conclusion, all three of the rapidly evolving imaging modalities mentioned in this article have unique advantages and limitations. Many complementary interactions are developing among them, and their continuing roles in cardiovascular diagnosis will further be defined by clinical experience and ongoing studies.

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3. The Automatic Implantable Cardioverter Defibrillator in the Treatment of Ventricular Arrhythmias

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The automatic implantable cardioverter defibrillator (AICD) appears to be a major therapeutic advancement in the management of life-threatening ventricular arrhythmias.[1-5] The efficacy of this device is based on its ability to continuously monitor the ventricular rhythm, accurately and rapidly sense ventricular tachyarrhythmias, and finally to deliver enough energy to the myocardium to depolarize a critical mass of ventricular muscle and effectively terminate the arrhythmia.[2]

Physical characteristics of AICD system

The currently available AICD system has three components (1) the battery-operated pulse generator; (2) a rate-sensing lead(s); and (3) two defibrillating leads. The generator consists of the battery, the capacitors, and the electronic model, which are all contained in a titanium shell. The generator is rectangular in shape with the dimensions of 11.7 x 7.1 x 2.5 cm and weighs 290 g. The ratesensing electrodes consist either of an epicardial bipolar lead positioned at the right ventricular apex or a bipole formed by two closely spaced (within 1-2 cm) unipolar myocardial screws in lead, usually inserted on the epicardial surface of the lateral wall of the left ventricle. The transcardiac energy delivery system is composed of either an epicardial patch combined with a spring lead that is positioned at the junction of the superior vena cava and right atrium, or in combination with a second patch. The patches vary in size from 14-28 cm.[2] If two patches are used, one is routinely placed over the right ventricle, while the other is secured on the posterior lateral surface of the left ventricle.[6]

There are two models of the AICD currently available, the AICD-B and the AICD-BR. The former requires triggering by an abnormal rate (electrogram-to-electrogram intervals as recorded by the bipolar-sensing electrode, which is less than a preset value) and an abnormal morphology (a significant absence of the isoelectric interval) as detected by the morphology-sensing defibrillating leads.[2] The AICD-BR requires only that the rate that is sensed be above the preset value. The AICD requires 5-20 seconds for recognition of a ventricular tachyarrhythmia and then 5-10 seconds for the battery of the pulse generator to charge the capacitors.[6] Once fully charged (a total elapsed time of 10-30 seconds), the first 25-30 J shock is delivered synchronously with the sensed electrogram. If the tachycardia is not terminated, this sequence will be repeated for up to three more cycles, each of which delivers an increased energy level (usually 28-32 J at each discharge). After the fourth countershock, the AICD requires 35 seconds of a rhythm other than that which would normally activate the device in order to be reset and have the potential to recognize a tachyarrhythmia and discharge appropriately.

Candidates for the AICD

The AICD is currently available for any patient determined to be at high risk for sudden cardiac death. These patients have usually survived a cardiac arrest and have a sustained ventricular arrhythmia not controlled by antiarrhythmic drug therapy and not associated with reversible ischemia, acute myocardial infarction, electrolyte abnormality, or drug therapy.[2-7] We have defined five groups of patients who may be ideal candidates for the AICD.[4]

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1. Patients experiencing a cardiac arrest in the setting of chronic coronary artery disease, who have inducible ventricular tachycardia or fibrillation that remains inducible and poorly tolerated hemodynamically, despite antiarrhythmic therapy. The patient should not considered a suitable candidate for surgery aimed at ablating arrhythmogenic areas.[5,8]

2. Patients with an idiopathic dilated cardiomyopathy and a history of a sustained ventricular tachyarrhythmia that resulted in hemodynamic collapse. The use of programmed electrical stimulation to guide pharmacological therapy had proven less useful in this patient population. Sustained uniform ventricular tachycardia is induced uncommonly during programmed stimulation, and suppression of the inducible ventricular tachycardia with antiarrhythmic therapy is rare.[9,10]

3. Patients with "torsade de pointes" not associated with drug therapy or transient metabolic abnormalities whose arrhythmias are not prevented by therapy with ß-blocking agents or by cardiac pacing.

4. Patients with a history of a cardiac arrest or documented ventricular tachycardia, which led to hemodynamic collapse, whose arrhythmias are not inducible by programmed electrical stimulation. The inability to initiate the arrhythmia precludes the use of pharmacological therapy guided by electrophysiological testing. Despite the fact that the arrhythmia is not inducible, these patients remain at risk for a life-threatening arrhythmia recurrence. Of note, these patients should have not evidence suggesting that acute ischemia precipitates the arrhythmia.

5. Patients who are undergoing ablative arrhythmia surgery (subendocardial resection) who, at the time of surgery are deemed to have an increased risk for arrhythmia recurrence (i.e., those with a history of rapid ventricular tachycardia or a cardiac arrest, in whom sites of origin for all tachyarrhythmias cannot be localized by pre-operative or intraoperative mapping techniques). This group may be ideally suited for the placement of the epicardial patch leads without implantation of the pulse generator at the time of ablative surgery. if a ventricular tachyarrhythmia is still inducible postoperatively, the generator could be implanted without repeat thoracotomy or sternotomy.[11]

Preimplantation evaluation

Every patient should have extensive preimplantation evaluation when being considered for the AICD. The information obtained during the preoperative evaluation may avoid some frequently encountered postoperative complications. A 24-hour Holter monitor should be used to determine the frequency of nonsustained ventricular tachycardia and presence of supraventricular tachycardias. The AICD can be triggered by these arrhythmias, which rarely cause hemodynamic compromise and loss of consciousness. Because discharge of the AICD will occur while the patient is awake, the patient may experience extreme discomfort. The frequent discharge of the device will also lead to early battery depletion.

Exercise stress testing should also be performed to insure that the maximum achievable sinus rate or maximum ventricular response to atrial fibrillation does not exceed the desired preset rate cut-off that will trigger the AICD. Similarly, electrophysiological testing should be performed in all patients prior to implantation, or order to demonstrate that the rates of all tachycardias initiated that result in hemodynamic compromise are above the rate cut-off selected.

To avoid early battery depletion associated with frequent episodes of spontaneous ventricular tachycardia, and to avoid recurrent syncopal symptoms that occur prior to AICD discharge, antiarrhythmic therapy may be necessary to decrease the potential for sustained ventricular tachyarrhythmias.

If pharmacological therapy is indicated, we feel that programmed electrical stimulation should be performed after institution of the therapy but before AICD implantation. This is necessary because most antiarrhythmic agents tend to increase the ventricular tachycardia cycle length. The rate of the arrhythmia may slow below the rate required for triggering the AICD and the arrhythmia will persist. These slowed arrhythmics may still produce hemodynamic compromise or result in symptoms related to the development of congestive heart failure. Also, many antiarrhythmic agents have the potential to alter defibrillation thresholds.[12,13] Thus, antiarrhythmic agents instituted postoperatively may prevent the device from appropriately sensing and or effectively terminating the arrhythmia.

Implantation

Several surgical approaches are currently available for the placement of the patch leads. Median sternotomy, left lateral thoracotomy, subxiphoid, and subcostal approaches have been used for placement of the leads. The subcostal and subxiphoid approaches tend to associated with a shorter postoperative recovery period. The subcostal, but not the subxiphoid approach, allows for placement of a two-patch system. A median sternotomy permits direct visualization of the entire heart and is generally used when concomitant procedures (i.e., coronary bypass grafting) are planned.

The most frequently used surgical approach for patch lead placement is via a left lateral thoracotomy.[3-6] This approach also permits easy access for the placement of multiple leads and allows for direct visualization.

When the two-patch system is used, one patch is generally placed over the right ventricle, while the second is positioned over the postlateral region of the left ventricle. If only one patch is used, it is placed over the apex of the left ventricle and a spring electrode is introduced via the left internal jugular or subclavian vein and positioned at the junction of the right atrium and superior vena cava. A right ventricular endocardial rate-sensing lead can be introduced transvenously if the surgical approach does not allow for the epicardial placement of the rate-sensing leads. All leads are tunneled subcutaneously to the generator pocket, which is routinely positioned subcutaneously in the left upper quadrant of the abdomen. The signal from the rate-sensing lead(s) should have an amplitude >6mV.[6] If the electrogram is small, such as one would see in an infarcted area, inaccurate rate-sensing may occur.

Following lead placement and before generation implantation, ventricular tachycardia, if present preoperatively, and ventricular fibrillation are initiated to determine whether the lead configuration used results in effective arrhythmia termination. Because the AICD delivers 16-30 J of energy, it is desirable to achieve a patch-patch or patch-spring lead electrode configuration that results in effective defibrillation with 20 J or less. This defibrillation threshold allows for a margin of safety should either the anatomic substrate for the arrhythmias change or drug therapy that may alter the defibrillation threshold needs to be initiated.

We found the large patch-to-large patch electrode configuration to be better than the spring-to-patch or small patch-to-small patch configuration in achieving the lowest defibrillation threshold. Finally, the leads are attached to the generator and the arrhythmia reinitiated in order to demonstrate that the AICD generator functions normally, and senses and terminates the arrhythmia.

Interaction of the AICD with pacemakers

Conduction system disease and symptomatic bradyarrhythmias are frequently found in patients with chronic coronary artery disease who experience life-threatening ventricular arrhythmias. Concomitant use of a permanent pacemaker with the AICD may frequently be necessary in patient management. There are two specific problems that may be encountered, related to interaction of the patient's packmaker and the AICD.

First, a unipolar pacing stimulus and the ventricular depolarization may each be counted as a ventricular depolarization by the rate-sensing electrodes. This sensed rate may exceed the rate limit of the AICD, particularly when associated with a burst of nonsustained ventricular tachycardia.[3-7] The second potential pacemaker-AICD interaction may occur during ventricular fibrillation. The pacemaker may fail to recognize the fibrillation and continue to pace during the arrhythmia. The AICD may sense the large amplitude pacemaker stimulus and fail to recognize the faster rhythm, thus failing to deliver a potentially life-saving discharge.[3-7] These pacemaker-ACID interactions may be avoided by (1) using a bipolar, rather than a unipolar pacing system that will produce a lower amplitude pacing stimulus, and (2) by positioning the AICD rate-sensing leads at the maximum distance from the bradyarrhythmia pacing lead. The pacemaker should also be programmed to have the smallest effective pulse amplitude and the maximum sensitivity.

The efficacy of the AICD

At the Hospital of the University of Pennsylvania, we have successfully implanted 38 AICD devices. Thirty-six patients had suffered a cardiac arrest and two patients presented with syncope. The latter two patients had rapid ventricular tachycardia initiated reproducibly during programmed stimulation. The mean ejection fraction of our patient population was 34%. During a mean fol-

low-up of 13.5 months (ranging 1.5-28 months), no patient has died suddenly. Fifteen of our patients have had the AICD discharge at least once for an electrocardiographically documented or suspected arrhythmia (Fig 1). Thirty-two of the 38 patients in whom the AICD was implanted are alive. The remaining six patients died secondary to refractory heart failure, sepsis, respiratory failure due to amiodarone pulmonary toxicity, or at the time of attempted cardiac transplantation. No patient died of sudden cardiac death. Thus, the overall survival during our follow-up period was 82.1%. Our results compare favorably with those found by other investigators.[3,14]

Complications of the AICD

Complications associated with the AICD can be divided into two categories, early or perioperative events and late complications. The mot common perioperative events are those related to the surgical procedure: atelectasis with or without pneumonia, pneumothorax, serosanguinous pleural effusions, and wound infections. Seromatous fluid accumulation at the site of the abdominal generator pocket are commonly noted. The seromas usually resolve spontaneously. Large seromatous collections may be managed by percutaneous needle aspiration. If leads are placed intravenously, there is also the risk of vascular thrombosis, particularly in association with the use of the spring lead.[4,5]

In our series of 38 consecutive AICD implantations, two perioperative complications could be uniquely attributed to the AICD. One patient developed bleeding secondary to the epicardial plaque electrode eroding into a small epicardial coronary artery. In a second patient, an embolic cerebral vascular event occuring two days after AICD implantation was felt to be secondary to termination of the patient's longstanding atrial fibrillation at the time of intraoperative AICD testing.

One of the most common late complications is the discharge of the AICD in the absence of symptoms attributed to ventricular tachycardia or fibrillation.[3,4] This complication has occurred in 20% of our patients. We have documented AICD discharge during atrial fibrillation, sinus tachycardia, or nonsustained ventricular tachycardia, but most frequently, no electrocardiographic monitoring is being performed at the time of device discharge. Migration of leads placed intravascularly has also been a frequently reported late problem[3,4] We have found that this problem can be obviated by the use of silastic anchors at the venous insertion site or by using a totally epicardial approach for lead placement.

Future advancements

Although the AICD has added a new dimension to the care of patients with malignant ventricular arrhythmias, several modifications of the device are necessary for optimum function. A reduction in the physical size of the generator would be cosmetically, as well as technically, desirable. Programability of triggering rate selectivity and the amount of energy delivered would be advantageous, especially in those patients requiring changes in antiarrhythmic therapy that may alter both tachycardia rates and defibrillation thresholds.[15]

Incorporation of back-up bradycardia pacing capabilities for those patients who develop transient bradycardia postcardioversion, or for those patients that need chronic pacing, would obviate the need for two separate generators.[16,17] Incorporation of antitachycardia pacing capabilities with back-up defibrillating potential to manage tachycardia acceleration may make the device the ideal method of treating patients who have infrequent episodes of sustained ventricular tachycardia which is tolerated hemodynamically. A total endocardial lead system would eliminate the need and risk of a thoractomy.[5,18] A sequential endocardial pulse delivery system may make this possible.[19]

Finally, recent work at our institution also suggests that various new pacing modalities may help prevent the development of ventricular tachycardia.[20] These preventive techniques may be incorporated in the AICD system. It is our hope that with the advancement of technology, a flexible, multipurpose AICD system will find increasing application in the management of sustained ventricular arrhythmias.

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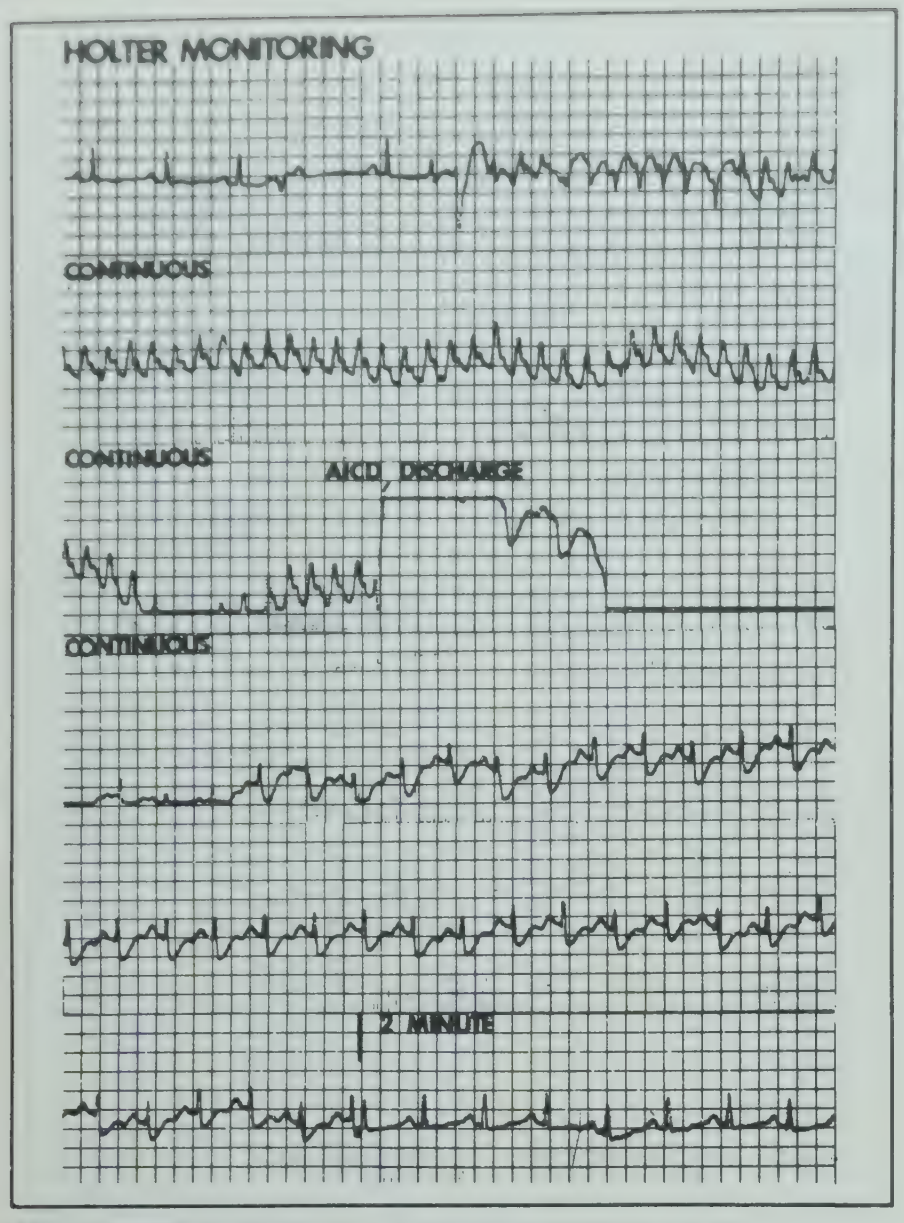

FIG. 1: Recognition and termination of spontaneous ventricular tachycardia by automatic implantable cardioverter defibrillator (AICD) documented

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4. Current Techniques Used to Detect Silent Myocardial Ischemia

Michael E. Assey, M.D.

When myocardial oxygen demand exceeds supply, ischemia results and when this ischemia fails to elicit angina or an equivalent symptom, the term "silent myocardial ischemia" is applied. During the past 15 years, much has been learned about the prevalence, prognosis, and pathophysiology of silent myocardial ischemia. This article limits itself to a discussion of detection while referring the reader to several excellent overviews of silent myocardial ischemia.[1-4]

A discussion of detection is timely because physicians are currently being asked to develop scientifically rational but cost-effective means of detection. A recent legal decision in the United States held physicians liable for failing to search for and treat silent myocardial ischemia in a patient who subsequently presented with sudden cardiac death. Such legal pressure further emphasizes the need for accurate means of detection.

The concept of an ischemia cascade has been proposed, emphasizing that angina, if present at all, is a late manifestation of myocardial ischemia.[5] Generally speaking, myocardial functional abnormalities, hemodynamic changes, and electrocardiographic manifestations—reflecting myocardial malperfusion—occur prior to angina pectoris. In patients with silent myocardial ischemia, due to a partially or completely defective anginal warning system, the demonstration of these vents allows a diagnosis of silent myocardial ischemia (Table 1.)

General considerations concerning ischemia detection

The value of any detection technique depends on the procedure's sensitivity and specificity as well as the prevalence of the disease (myocardial ischemia) in the population studied. For example, right angle ST segment depression during exercise testing of a middle-aged man with classical angina and known coronary artery disease is almost certain to represent myocardial ischemia, even in the absence of chest pain. This is because the pretest likelihood of having coronary artery disease and resulting myocardial ischemia is so high that an abnormal test is unlikely to be false-positive. Contrast this, however, with an equally positive exercise test in an asymptomatic middle-aged man in whom the likelihood of having coronary disease is less than 5%. Using the same detection technique, the likelihood that the ST segment depression is due to myocardial ischemia is less than 20%. Clearly then when evaluating the relative usefulness of various diagnostic techniques, one must consider not only sensitivity and specificity but the disease prevalence as well.

Prevalence becomes particularly germane when screening for type I silent myocardial ischemia. According to the classification of Cohn,[6] individuals with this type of silent myocardial ischemia are totally symptomatic, presumably due to a defective anginal warning system. Prevalence becomes less important when screening for type II (postinfarction silent myocardial ischemia) or type III patients (those with angina as well as silent ischemia). Most early studies investigated the prevalence and prognosis of silent myocardial ischemia in type II and type III patients. When similar means of detection are applied in type I individuals, a much lower pretest likelihood seriously hampers the predictive accuracy of the applied detection techniques.

Furthermore, coronary angiography, which is the conventional gold standard for assessing the accuracy of noninvasive techniques, may not truly reflect myocardial ischemia. In fact, myocardial ischemia should not be equated with coronary artery disease because some atherosclerotic lesions, identified at angiography or necropsy, may not produce silent or symptomatic ischemia. Also, as seen with aortic stenosis, coronary artery spasm, and syndrome X, ischemia may exist despite normal epicardial coronary arteries.

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Detecting silent myocardial ischemia: Resting electrocardiogram (ECG)

An ECG obtained during an episode of chest pain or a suspected cardiopulmonary symptom is of obvious value in determining whether or not the symptom is due to myocardial ischemia. By definition, this approach is not applicable in screening for silent ischemia in which case symptoms are absent or so atypical that they fail to alert the physician to perform an ECG,. The standard ECG may, however, identify patients as having coronary artery disease and significant myocardial ischemia by uncovering an unrecognized (or truly silent) myocardial infarction. In the Framingham Heart Study, one-fourth of myocardial infarctions were diagnosed only by an abnormal ECG obtained every two years as part of the study protocol.[7] These infarcts were either totally silent (no symptoms of any type) or were associated with symptoms so atypical as to escape recognition. The surprisingly high silent infarction rate must surely be an underestimate of the true frequency of silent infarction. Since the diagnosis was made on the basis of new pathologic Q waves or loss of R waves, non-Q wave infarctions would not have been included. Patients dying during the two-year interim would not have been analyzed and 10-25% of patients will lose their ECG stigmata of infarction during a two-year interval.

The silent myocardial infarctions, however, were not benign. The likelihood of developing congestive heart failure, total cardiovascular mortality, and sudden cardiac death risks were equal in the silent and symptomatic infarction patients. Classically, the silent infarctions were more common in women, patients without prior angina and when the inferior wall of the left ventricle was the infarct site.

Continuous ECG monitoring

Chierchia et al studied 14 patients having rest angina with simultaneous hemodynamic and continuous ECG monitoring.[8] Two-hundred ninety-three episodes of transient ST segment and Twave changes were identified, 84% of which were completely asymptomatic. The majority of these episodes were accompanied by an elevation of left ventricular end-diastolic or pulmonary artery diastolic pressure. Furthermore, great cardiac vein oxygen saturation measured in three of the patients showed an increased myocardial oxygen extraction preceding and accompanying asymptomatic ECG changes. This helped prove that these asymptomatic ECG changes represented true transient myocardial ischemia. In general, the silent ischemia episodes were shorter and were associated with less impairment of left ventricular function as compared with the symptomatic episodes.

The use of continuous ECG monitoring has proved valuable in establishing prognosis when silent myocardial ischemia is detected in patients with unstable angina pectoris. Gottlieb evaluated 70 patients hospitalized with unstable angina defined as chest pain with transient ST Segment shifts. When treated with long acting nitrates, propranolol and nifedipine, 33 of the 70' patients were without ischemic ST segment shifts. The remaining 37 patients had 205 ischemic ST segment shifts, 90% of which were painless. At 30 days of follow-up, the group with silent myocardial ischemia, identified in this manner, had a statistically significant higher incidence of myocardial infarction or need for coronary revascularization. Multivariant analysis showed silent ischemia to be the most potent predictor of subsequent cardiac events.[10]

Nademanee used continuous ECG monitoring to study a similar group of unstable angina patients.[11] Although clinically stable on antianginal therapy, these patients demonstrated prolonged ischemic ST segment shifts, 90% of which were painless. The prognosis worsened as the duration of silent ischemia increased. In 18 patients with prolonged ischemia, defined as greater than 60 minutes of ST segment depression, the cardiac event rate was particularly high. At a follow-up between three and six months there were five myocardial infarctions resulting in two deaths and two coronary bypass surgeries for postinfarction angina. Eleven other coronary bypass surgeries and one coronary angioplasty were required for medically refractory angina. Such studies demonstrate that continuous ECG monitoring of ST segment shifts not only demonstrates a high prevalence of silent myocardial ischemia but identifies patients at high risk for subsequent cardiac events, despite apparent clinical stability.

Ambulatory ECG monitoring

For the stable, ambulatory patient ECG monitoring to assess ischemia need not be confined to continuous ECG monitoring in the coronary care unit. Over a quarter of a century ago, Holter suggested that ambulatory ECG monitoring might be useful in diagnosing myocardial ischemia and

assessing the efficacy of anti-ischemic therapy.[12] Indeed, much of our knowledge about the pathophysiology of silent myocardial ischemia has come from ambulatory ECG monitoring. In general, these studies have shown that most ischemic episodes in patients with established coronary artery disease are silent. On average, 75% of all ischemic episodes, defined by ambulatory ECG monitoring, occur without angina or equivalent symptom.[13-16] This means that a patient having three episodes of angina per day may in fact have a dozen ischemic episodes, with the silent episodes representing the bulk of the total ischemic burden. These silent ischemic episodes are surprisingly prolonged, typically lasting six to 12 minutes, although in an individual patient with both silent and symptomatic episodes, those associated with angina are generally longer and are associated with more ST segment depression.

Most of the episodes of silent myocardial ischemia uncovered by ambulatory ECG monitoring are not associated with an increased heart rate, nor do they occur with activities associated with increased myocardial oxygen demand.[13,14] This implies a supply side pathophysiology, with a primary reduction in myocardial oxygen supply mediating most silent ischemic events. Finally ambulatory ECG monitoring studies have shown that silent ischemia has a peculiar circadian variation similar to that seen for myocardial infarction and sudden cardiac death. Rocco et al[17] demonstrated that 39% of all ischemic episodes (87% of which were silent) and 47% of the total ischemia duration occurred between 6:00 a.m. and noon. That period of time is also the peak frequency for myocardial infarction and sudden cardiac death.

The use of Holter monitoring to assess ischemia has not been accepted without criticism. In the late 1970s, several authors cautioned against this approach, fearing a high frequency of false-positive results.[18,19] As our understanding of the frequency response characteristics of available systems improved[20] and patient selection was better defined,[21] the technique has gained wider acceptance and is now widely used.

Initially it appeared that the low frequency ST segment shifts could only be reliably reproduced by frequency modulated Holter systems. At present, however, a number of FM and AM systems meet the requirements of the American Heart Association, which specifies that systems detect frequencies between 0.05 and 100 Hz, that they have a constant amplitude versus frequency response, have minimal phase shift, and be free of baseline artifacts. Berman et al have pointed out, however, that these specifications are often reported only for the amplifier itself, and the other important components of the system, including the recorder, playback system, and printout device, are not always considered.[22] It is for this reason that we are reluctant to accept the information provided by recorders, even FM recorders, that do not allow a full disclosure of accumulated data.

One of the important early studies proving the validity of this approach was that of Deanfield et al.[14] They studied 30 patients with effort angina and positive exercise treadmill tests, most of whom had angiographic evidence of coronary atherosclerosis. All patients had four consecutive days of monitoring yielding 1,934 episodes of right angle or down-sloping ST segment depression. Only 24% of these ischemic ST segment shifts were accompanied by angina. To corroborate that the ST segment shifts truly reflected myocardial ischemia, positron emission tomography (PET scanning) with ^{82}rubidium was performed. There was evidence of regional depression occurring spontaneously, or induced during exercise or by cold pressor studies.

More important than choosing a particular manufacturer is adherence to basic principles designed to enhance the predictive accuracy of the technique. First, patients with resting repolarization changes, as seen with left bundle branch block, or in whom ST segment shifts are induced by postural changes or hyperventilation should be excluded from study by this technique. We instruct our technicians to obtain a baseline ECG with the patient supine, lying on either side, standing, and during hyperventilation. For a test to be considered positive for myocardial ischemia (and in the absence of symptoms indicating silent myocardial ischemia) the "1 X 1 X 1 rule" is utilized. There must be at least 1 mm or more of ST segment depression lasting at least one minute and separated by one minute or more of baseline ST segment position. The use of multiple leads enhances the sensitivity of this technique.

The optimal duration of monitoring remains unclear. Coy et al[23] investigated 17 totally asymptomatic men with positive ST segment shifts during treadmill testing and found silent myocardial ischemic ST segment in 11 patients. All 11 had significant coronary artery disease by angiogra-

phy. During the first 24 hours of ambulatory ECG monitoring, only six of 11 patients showed silent ischema. Two others has silent ischemia when the monitoring period was extended to 48 hours, while three patients required 72 hours of monitoring to demonstrate any degree of myocardial ischemia. Tzivoni et al[24] studied 20 patients with chronic stable angina, positive treadmill tests for ischemia and proved coronary artery disease with 72 hours of Holter monitoring. A total of 389 ischemic episodes was noted, 73% of which were silent. The investigators found a marked variability between patients in the number of ischemia episodes (range 2-15 per day), duration of ischemia (range 6-419 minutes per day), and degree of maximal ST segment depression. Daily variability in the number of ischemic episodes was 36% for an individual patient, while duration varied 51% and maximal degree of ST segment depression varied 31%. However, a single day of monitoring picked up almost 80% of the maximal number of ischemic episodes, two-thirds of the maximal duration and 84% of the maximal ST segment depression. Accordingly, these authors suggested that a single 24-hour monitor period was adequate for clinical purposes, although because of the spontaneous variability, drug study analyses would require at least 48 hours of monitoring.

Ambulatory ECG monitoring of patients with stable coronary artery disease also have prognostic value. DeWood and Rozanski[25] compared 26 ambulatory patients with silent ischemia with patients of similar anatomy showing no ischemia. At three years of follow-up, the silent ischemia patients had a significantly higher cardiac event rate (46% vs 9%) and a higher total mortality (23% vs 6%).

Standard exercise testing

At present, exercise testing is most often used to uncover silent myocardial ischemia. The predictive accuracy of a positive test varies directly with disease prevalence and, therefore, comments about the utility of this technique in type II or type III patients may not be applicable to the screening of totally asymptomatic individuals. Lindsey and Cohn[26] studied 122 consecutive patients with stable coronary disease and abnormal coronary angiograms using a double two-step test protocol. Thirty-six percent of all ischemic episodes were silent, despite clinical and angiographic similarity between silent and symptomatic patients. Weiner et al[27] used bicycle ergometry or Bruce protocol treadmill testing to study 302 patients undergoing both exercise testing and coronary angiography. In 146 patients, an ischemic ECG response and significant coronary disease was present, with 44% having exercise-induced silent myocardial ischemia. Two-thousand nine hundred eighty-two patients from the Coronary Artery Surgery Study were classified on the basis of ST segment response and symptoms during treadmill testing.[28] Those with ischemic ST segment shifts without angina (silent ischemia) were compared with those who experienced angina alone and those with both angina and ischemic ST segment shifts. The prognosis for the silent ischemia group was not different from the symtomatic ischemia patients. Indeed, the prognosis was directly related to the underlying coronary anatomy, reflecting the amount of myocardial ischemia. For example, patients with triple-vessel coronary artery disease and silent myocardial ischemia had a 6% annual mortality rate at seven years of follow-up. In contrast, the survival was 86%—a 2% annual mortality rate—in single vessel disease patients.

Falcone studied 473 patients undergoing both coronary angiography and exercise testing by supine bicycle ergometry.[29] The prevalence of silent myocardial ischemia was 43%. Individuals with silent ishemia had a longer exercise duration, reached a higher peak double product, manifested a greater degree of ST segment depression at peak exercise and more exercise-induced ventricular ectopy,. Survival curves, however, in the medically treated patients with exercise-induced silent ischemia were similar to those with symptomatic ischemia.

In contrast to these studies in type III silent ischemia patients, there are only a few exercise studies in type I individuals with angiographic corroboration of results. Foremost of these is the Norwegian Study of Erikksen and Thaulow.[30] Two-thousand and fourteen middle-aged males were screened and angiography was offered to all those with angina on interview, angina during treadmill testing, ECG evidence of prior infarction or ischemic treadmill test result. There were only 50 asymptomatic patients with both a positive exercise treadmill test and abnormal coronary angiography. This low disease prevalence, approximately 2%, is a major problem when any type of screening procedure for silent ischemia is used.

The importance of screening for type I silent ischemia is underscored by the subsequent clinical course of the 50 patients in the Norwegian

Study. Virtually all who had a second coronary angiogram showed progression of coronary atherosclerosis. At 13 years of followup,[31] 12 of these asymptomatic patients had subsequently died of cardiac causes. In the remaining 38, 15 had sustained myocardial infarctions while 11 others had developed angina pectoris. The fact that all but one of the deaths occurred in patients with two-vessel or three-vessel coronary artery disease underscored the fact that it is the degree of myocardial ischemia, rather than the presence or absence of symptoms, that determines prognosis.

The standard exercise treadmill test is attractive as a screening procedure for silent ischemia because it can be used in the office at a relatively low cost. However, it must be remembered that a sensitivity of 60% and a specificity of 80% is less than optimal and, coupled with the low disease prevalence in the asymptomatic population, requires a second validating test for most positive results. On the other hand, we refer for coronary angiography those patients with strongly positive or early positive treadmill tests who have coronary risk factors even in the absence of cardiac symptoms.

Exercise testing vs Holter monitoring

Quyyumi et al[32] studied 100 consecutive patients undergoing exercise testing, ambulatory ECG monitoring, and coronary angiography for chest pain. Of the 74 patients with angiographically significant coronary disease, ST segment changes during 48 hours of monitoring were seen in 52 (sensitivity 77%). This was similar to the 73% sensitivity of standard exercise testing. Tzvoni et al[33] also showed equal sensitivity and specificity for ambulatory monitoring and exercise testing when type III patients were evaluated.

We view these tests as having complementary value in the identification of silent ischemia in type II and type III patients. For the type I patients, however, exercise testing is preferred to ambulatory ECG monitoring as a screening test for silent ischemia. In addition to the electrocardiographic change, important information about left ventricular systolic function (and subsequent prognosis) can be inferred from the duration of exercise and the hemodynamic response to stress. The greater amount of leads available during treadmill exercise testing allows one to uncover ischemia in certain areas of the myocardium (such as the high lateral wall), not detectable by standard Holter techniques.

Perfusion Scintigraphy

^{201}thallium imaging significantly improves the sensitivity and specificity of ischemia detection when compared with standard exercise testing. The 80-90% sensitivity and 90% specificity of ^{201}thallium stress imaging is particularly important when asymptomatic individuals are screened for silent myocardial ischemia. Imaging techniques are virtually essential in patients with resting repolarization changes and those taking medications (i.e., diuretics, digitalis) known to cause false-positive ST segment shifts during exercise.

^{201}thallium imaging is often used to validate a questionable or borderline positive routine exercise test. If the pretest likelihood of coronary artery disease is low (i.e., 5% in an asymptomatic individual) then a screening test with a sensitivity of 60% and specificity of 80% will have a post-test likelihood of ischemia in the face of a positive result of only 17%. Therefore, most the positive tests will be in individuals who do not have myocardial ischemia. Thallium exercise testing, with a better sensitivity and specificity, increases the likelihood that a positive test really indicates myocardial ischemia. Moreover, the combination of the ECG stress test and the perfusion scintigraphy test in an example of sequential Bayesian analysis. In this approach, the post-test likelihood of the first screening test is taken as the pretest likelihood for the second procedure. Although in screening type I individuals thallium imaging may not improve sensitivity, specificity is significantly improved. This decreases the likelihood that normal people will be labelled as having myocardial ischemia, which would detract from attempts to screen high risk patients for coronary artery disease.

Thallium stress testing is useful in type II (postinfarction) patients to assess residual ischemia in the infarct area or uncover ischemia remote from the infarct site. Our current approach is to image such patients during stress, four hours later (reperfusion scan) and, in the case of postinfarction patients with demonstrable scars, at 24 hours after exercise. Virtually all scars show some evidence of reperfusion, which is important prognostically because postinfarction silent myocardial ischemia has been shown to have independent prognostic significance.

Thallium stress testing that uncovers silent myocardial ischemia has prognostic value in stable angina patients as well. We evaluated 55 subje-

cts with thallium hypoperfusion during stress.[34] Twenty-seven patients demonstrated ischemia without symptoms (silent myocardial ischemia), whereas 28 patients had angina with their myocardial ischemia. The groups were similar in terms of left ventricular function, coronary anatomy, and conventional stress test characteristics, although the silent patients exercised longer and reached a higher peak-double product. Importantly, at 30 months of follow-up, there was a statistically significant higher incidence of myocardial infarction in the silent group. This indicates that far from being benign, thallium hypoperfusion during stress that is clinically silent increases the risk of myocardial infarction in at least some patients. Presumably these patients had an incomplete anginal warning system. Although they all had a history of angina (i.e., type III patients,), during stress they failed to have angina and thus their myocardial ischemia was unrecognized.

Recently an improvement in imaging techniques with thallium testing has been the application of single photonemission computerized tomography (SPECT). In our experience sensitivity and specificity of thallium stress testing has been further enhanced with this modification.

Patients with peripheral vascular disease are often suspected of having coronary disease and silent myocardial ischemia but their claudication prevents them from undergoing conventional exercise testing. In such patients, alternative techniques for silent ischemia detection are needed, because identification of significant ischemia would lead to preoperative coronary angiography and possibly myocardial revascularization prior to the planned surgical procedure. While several studies support the use of intravenous dipyridamole in such patients,[35] we have been impressed with the sensitivity and specificity of dobutamine stress thallium imaging, particularly when combined with SPECT. A color-enhanced dobutamine stress thallium SPECT test (bull's eye technique) in an elderly man with peripheral vascular disease but no angina was done. The stress image showed thallium hypoperfusion in the posterolateral left ventricular wall which normalized on redistribution studies four hours later. At coronary angiography, this patient had high grade stenoses in the obtuse marginal (posterolateral) branch of the circumflex coronary artery. Similarly another dobutamine stress thallium SPECT image in a man with an inferior defect, was done normalizing at rest. A search for silent ischemia in this patient was prompted by the finding of asymptomatic atrial fibrillation on an annual physical exam. Conventional stress testing was nondiagnostic due to poor aerobic fitness resulting from obesity.

A dobutamine stress thallium SPECT image was taken of a patient whose peripheral arterial vascular insufficiency prevented treadmill testing. The stress image demonstrated hypoperfusion of the septum and inferior hypoperfusion as well. The redistribution study, obtained four hours later, showed normalization of the septal perfusion with persistent defect (scar) in the inferior wall. At cardiac catheterization, this patient had a totally occluded right coronary artery (responsible for the inferior scar) and a 90% eccentric lesion in the proximal LAD causing the septal ischemia.

When dobutamine is used with thallium imaging a specific protocol is followed. Infusion is started at 10µg/ kg/ minute and, after five minutes, during which time blood pressure, 12-lead ECG, and cardiac rhythm are monitored, is increased to 20µg/kg/minute. If the patient fails to increase his resting heart rate to 100 beats per minute, or greater than 50% over the resting heart rate, atropine (0.3-0.6 mg intravenously) is administered. Our data suggest that the sensitivity and specificity of dobutamine thallium imaging combined with SPECT analysis exceed that of conventional thallium imaging and treadmill electrocardiographic analysis.

Mechanical abnormalities.

Silent myocardial ischemia can be recognized by the development of regional left ventricular wall motion abnormalities in both diastole and systole. These occur very early in the ischemic cascade, preceding the development of hemodynamic and ECG changes. During invasive cardiac catheterization, such abnormalities can be induced by atrial pacing and reversed by intravenous or sublingual nitroglycerin. Sharma et al used such contractile abnormalities to validate that ST segment shifts were ischemic in patients surviving out-of-hospital ventricular fibrillation.[36]

Bonow et al studied asymptomatic and mildly symptomatic individuals with radionuclear ventriculography in which ischemia is detected when a regional wall motion abnormality develops during stress and or there is a significant drop in left ventricular global ejection fraction.[37] All patients who died during medical therapy had triple ves-

sel coronary disease with stress induced ST segment depression as well as a decrease in left ventricular ejection fraction. Prognosis was the same for symptomatic and silent patients. Although sensitive, the radionuclear ventriculogram (stress MUGA) technique suffers from a lack of specificity. Hypertensive patients and individuals with nonischemic cardiomyopathy frequently show a drop in global left ventricular ejection fraction or a flat ejection fraction response to stress. Technical factors are also important and are related to gating abnormalities, particularly in the case of atrial fibrillation and computer processing errors.

Ambulatory monitoring of global left ventricular function (VEST) is now available commercially. A scintillation detector is placed over the cardiac blood pool and a background area of interest. This allows for a measurement of left ventricular ejection fraction at rest and under stress. Its usefulness appears to be in the validating of ambulatory ST segment shifts, excluding false-positive ECG changes.

Other detection techniques

In years past, myocardial ischemia was induced in the cardiac catheterization laboratory by atrial pacing. A certain percentage of these tests demonstrated silent myocardial ischemia. Although less frequently used today, some electrophysiologists have shown that silent myocardial ischemia, generally silent must be present to induce ventricular tachycardia.[38] Other metabolic tests are now available and include PET imaging with metabolic tracers. The combination of a metabolic tracer with a flow tracer has ben useful in differentiating stunned or hibernating myocardium from scar tissue. Although attractive in their sophistication, these tests play a relatively minor role in silent myocardial ischemia detection.

Table 1

ELECTROCARDIOGRAPHIC CHANGES	REVERSIBLE MYOCARDIAL HYPOPERFUSION	LEFT VENTRICULAR MECHANICAL CHANGES	HEMODYNAMIC CHANGES	METABOLI CHANGES
• Resting electardiogram	• 201 Thallium stress testing	• Excercise contrast ventriculography	• Excercise-induced increase in intra-cardiac pressures	• Excercise-induced lactate production
• Standard exercise testing	• Positron scanning with 82 rubidium	• Exercise radionuclear ventriculography		• Positron scannning with metabolic tracers
• Continuous electrocardiographic monitoring		• Exercise echocardiography		
• Ambulatory (Holter) monitoring		• Exercise VEST		

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5. *Endocardial Fulguration* - *A method for treatment of cardiac arrhythmias*

G. Fontaine, A. Cansell***

Rhythmology is a specialized subdivision of cardiology concerned with the study and treatment of cardiac arrhythmias, namely disturbances of normal heartbeat rhythm. One such condition is when the heart rate is decelerated, becoming slowed to the point where implantation of an artificial pacemaker may be necessary. An accelerated heart rate is however the far more common form of arrhythmia.

This condition may be associated with extrasystoles, which are abnormal and premature contractions of the heart, or tachycardia, namely extended periods during which the heart rate exceeds 100 per minute in the absence of physical exertion. It is possible for the patient to experience palpitations or indirect symptoms such as fatigue, dizziness or loss of consciousness. Too frequent occurrence of these symptoms or an overly excessive increase in heart rate can be life-threatening owing to the heart becoming incapable of fulfilling its function of maintaining the body's blood circulation. In the worst instance, tachycardia can lead to cardiac arrest and sudden death.

Previous methods of treating cardiac arrhythmias

Tachycardia is normally treated with drugs which distribute throughout the body, like all drugs, but concentrate preferentially in the cells of the heart. Their action is to control the heart rate by modifying the conditions of activation and propagations in the myocardial tissues. Drug therapy of limited duration is sufficient in some cases. In others, especially with young patients, episodes of tachycardia are current and drugs must be administered on a regular daily schedule or even several times a day over long periods of time, every interruption in medication provoking a relapse.

In the meantime a special pacemaker technique has been developed to terminate attacks of tachycardia, but it can only be employed in certain cases and requires prior investigation of the individual patient at a cardiac catheterization laboratory to determine its suitability and prospects. The examination involves introduction of a probe into the interior of the heart through a vein or artery. The probe, essentially an electrically insulated wire carrying electrodes at its tip, measures phenomena inside the heart and is used to deliver artificial pacemaker impulses.

The origin of arrhythmias may lie in any one of the heart chambers. *Supraventricular tachycardia* denotes disturbed rhythm caused by an ectopic focus in the atrium of the conducting pathway between the atria and ventricles.

Ventricular tachycardia originates in the ventricle and is frequently a consequence of earlier cardiac disease, it is also potentially graver. Only short-term improvement or palliation is to be obtained by treating ventricular tachycardias with drugs or the special pacemaker method described above, because neither of these produces any change in the cardiac tissue containing the arrhythmogenic substrate, meaning that it cannot effect real and lasting cure.

Before now, the only more radical approach available has been open-heart surgery, which necessitates surgical opening of the chest, temporary substitution of natural cardiac action by a heart-lung machine, and operating the interior of the heart in an attempt to correct the disorder, which can be done by incision into the arrhythmogenic area or by Cryosrugery. Such radical surgery is only performed when the patient's life is immediately endangered, since the operation itself entails a certain degree of risk and the prospects of it being successful are not assured. Moreover it has to be carried out by highly specialized teams, of which there are but a small number in the world.

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Endocardial fulguration

Endocardial fulguration is a new technique of ablating or modifying morbid tissue in tachycardia by means of electrodes attached to catheters similar to those employed for conventional intracardiac examination.

Through the electrode, a strong but brief electrical pulse—typically several thousand volts and 20 to 40 amperes of a few milliseconds duration—is applied to the abnormal tissue.

The current is generated by capacitative discharge between the electrode tip of the catheter positioned in the heart and a large metal plate placed on the patient's back. When the pulse is triggered, an electric spark is delivered from the electrode within the heart, producing a dual effect: punctiform burning of tissue due to the thermal energy released and alteration of the conductivity of the surrounding tissue due to the explosive impact of the shock wave accompanying the spark.

Before fulguration can be carried out, the exact target for treatment must be localized by mapping the stimulation phenomena taking place within the heart through extensive and intricate measurements. The time at which the stimulation wave passes several preselected points in the respective heart chamber is measured and compared with the heart's electrical activity as recorded by an external electrocardiograms.

Advantages

The most important advantage of the endocardial fulguration technique consists in it being an electrophysiological rather than a surgical approach, enabling it to be performed on severely ill patients with a high surgical risk although it must still be considered a radical method in view of the physical action produced on tissue at the arrhythmogenic zone. In contrast to surgery, repetition of the procedure if it is initially unsuccessful or only partially successful does not entail any problems.

Treatment may be either direct or indirect. In the direct method, the focus of the disorder itself is treated, as when fulguration is applied directly to the morbid tissue in ventricular tachycardia.

In indirect treatment, by contrast, the aim is not to fulgurize tissue at the arrhythmogenic zone in the atria, or between the atria and ventricles but to interrupt the normal conducting pathway between the atria and ventricles (the bundle of His). This is the preferred method of treatment for supraventricular tachycardia, because the arrhythmogenic zone is usually not exactly localizable in this type of arrhythmia and therefore cannot be treated directly whereas the atrioventricular bundle is readily localized.

Interruption of conduction by the atrioventricular bundle prevents transmission of atrial tachycardia to the ventricle, then enabling heart action to be normalized with a conventional pacemaker. Of these two forms of fulguration, the indirect methods could soon emerge as routine for interruption of the atrioventricular bundle, as its clinical evaluation is already well advanced.

Application

In addition to an anesthetist, the team performing endocardial fulguration must comprise at least four cardiologists, each familiar with a particular aspect of the procedure. One specialist is required to induce artificial tachycardia, a second to monitor blood pressure, a third to interpret the signals transmitted from intracardiac electrodes, and the fourth to operate the fulguration apparatus.

Permanent recording is made of all data obtained during the 4- to 5-hour procedure: ECG derivatives, signals from the fulguration catheter and other intracardiac probes, arterial blood pressure, and all other relevant information. The precise course of the catheter must also be monitored continuously and is recorded as an x-ray image on video tape.

Delivery of the fulguration pulse is controlled by countdown so as to be able to keep a proper check on all instruments and to concentrate the information as fully as possible. After discharge, the success of treatment is investigated and, if necessary, a second or several more pulses can be delivered. On completion of treatment, the patient is continuously monitored in the intensive care unit (ECG and possibly intracardiac blood measurement), but is able to leave bed the next day.

Clinical results

Using special materials, our Paris group at the Jean Rostand Hospital in Ivry has investigated 20 patients over a period of 17 months. Twelve of these underwent treatment for supraventricular

tachycardia and results were generally successful, the maximum assessment time being 17 months. The experience gained corroborates results obtained by other groups, especially in the U.S.A.

The other eight patients were treated for ventricular tachycardia. Good partial success has been achieved to date. Localization of the target for treatment still presents many problems and the final version of the protocol has only recently been established. Considering the critical condition of the cases treated (some near death), the results achieved so far may be considered most impressive.

Application of the endocardial fulguration technique to human patients is still quite new and our group is regarded as that possessing the greatest experience in this specialized method of treating ventricular tachycardia. It is a highly promising technique but its broader application is predicted on development of apparatus which will enable all steps of the procedure to be performed with relative ease.

MEDICAL IMAGING

6. Present and Future Perspectives of Application and Utilisation of Modern Technology in Medical Imaging

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I Introduction

One gets easily bewildered at the explosive growth of new technologies as exist today in field of medical imaging. With a single article will it be possible to summarise some of the major issues of imaging[1] —that is the challenge. Even though the obvious answer to the question is no, there are certain issues that need to be put into perspective since these represent major social or economic issues in health care delivery. Hence in the following paragraphs, presentation in brief will include
(a) interventional radiology,
(b) recent advances in contrast agents,
(c) increasing use of digital X'ray imaging,
(d) development of new radiopharmaceuticals,
(e) realtime and Doppler ultrasound,
(f) computed tomography (CT),
(g) advancements in Magnetic Resonance Imaging (MRI)
(h) movements towards Picture Archiving and Communication System (PACS) and
(i) making X'ray devices 'intelligent'.
However I wish to reiterate, before starting, that due attention must still be given to the immense role that plain films perform in medical diagnosis and especially so, when in the majority of the developing countries most of the population live in rural areas and about half the rural hospitals in these countries do not have X'ray units. paradoxically 80% of such rural patients suffering from trauma, chest disease or less frequently, an acute abdominal condition, can be treated more satisfactorily following a simple radiographic examination.

II Major Advances in Imaging

A. Interventional Radiology

The term interventional radiology relates to a subspeciality of radiology dealing with a variety of percutaneous image-guided alternative or aids to surgery. This relatively new discipline encompasses a series of invasive procedures which are performed either under fluoroscopic guidance or under Computed Tomography (CT) and ultrasound guidance:

a) *Percutaneous biopsies* (organs, bones, soft tissues etc.) - under the guidance of any one of a number of imaging modalities - including CT, ultrasound and fluoroscopy - a biopsy needle is placed in desired location and a small amount of tissue removed which is then sent for cytologic study to arrive at a definitive diagnosis within a very short time.

b) Percutaneous drainages -

i) Biliary drainages : internal, external
ii) Nephrostomies
iii) Stent Placements
iv) Abscesses

The one feature common to all of these procedures is the extensive use of ultra sound and CT for the pinpoint localisation of the target. Once the obstructed system or fluid collection has been localised, the catheter is placed percutaneously under local anasthesia and aseptic precaution, and decompression can begin. These minimally invasive procedures offer a viable alternative to surgery with comparable, and in many cases, lower morbidity and mortality rates.

c) Percutaneous extraction -

i) Calculi (gall stones, kidney stones)
ii) Foreign bodies (fractured intravascular catheters, pacemaker wires)

High technology (high frequency ultrasound probes, lasers) combined with ready access provided by biliary and nephrostomy catheters allows relatively easy access to assorted calculi

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which can then be (i) removed with a basket (ii) fragmented and suctioned out by lasers or ultrasound or (iii) dissolved by infusing appropriate solutions through the catheter. Radiologists are frequently called up to remove dislodged or fractured devices like plastic angiocatheters, central venous lines and Swan-Ganz catheters from the pulmonary artery or subclavian vein; many of these areas which were accessible until recently by complicated and extensive surgical procedures can now be done safely and economically under non-invasive radiologic guidance.

d) Vascular interventional procedures

Vascular interventional radiology deals with either opening up of narrowed blood vessels called Percutaneous Transluminal Angioplasty (PTA) or, closing off of blood vessels called Embolization.

i) PTA: Under fluoroscopic control and utilising a range of guidewires and soft catheters, the stenosed arterial segments or totally occluded arterial segment is traversed with a guidewire followed by an angiography catheter. The guidewire is then exchanged for an appropriate angioplasty balloon catheter, which after being placed across the structure is inflated for a few seconds in the case of coronary angioplasty and 30 seconds for most other vessels. The initial application was in lower limb arteries but current application extends to the upper limb, vertebral, carotid, renal and visceral arteries. The same mechanism is used for dilating coronary arteries, oesophageal strictures and strictures of the biliary tree.

ii) Embolization - Rapid control of massive gastro-intestinal (GI) bleeding is still one of the most common interventional emergencies. Significant advances in the field include fluoroscopically guided catheters, rapid setting glues and particles, as well as metal coils and detachable balloon catheters; the end result of these various devices is the occlusion of an artery proximal to the site of bleeding. In the last 15 years or so, this field of vascular occlusive therapy has undergone an exponential expansion with refinements in catheterisation techniques, the developments of newer catheter materials and steerable guide wires, and the applications range from the management of arteriovenous malformations of the brain to traumatic lesions of the pelvis.,

e) Fibrinolytic Therapy -

Under imaging guidance (generally fluoroscopic) a catheter is placed in the occluded vessel. Streptokinase, urokinase, etc. is then infused through the catheter in an effort to dissolve the clot, rapidly and effectively. The indwelling catheter also allows repeated injections of contrast materials, so that dissolution of the clot and restoration of vessel patency can be simply and frequently monitored.

The field of interventional radiology is developing with new techniques emerging almost daily. The end result of these developments is shorter hospital stays, reduced medical costs, and improved patient care.

B, Recent Advances in Contrast Agents

To enhance the visualisation of certain structures in the body, all contrast agents in radiology and the intravascular contrast agents currently utilised have iodine atoms attached to fully substituted benzene rings. Compounds that were thought to offer increased safety compared to conventional agents, were developed using the same basic principle in the late 1960s and early 1970s. The older conventional agents (developed in 1950s) possess osmolarity from approximately 800-2000 mOsm/kg as against osmolarity of blood 300 mOsm/kg; many of the complications like general systemic, renal, cardiac and peripheral vascular effects with conventional agents can be traced directly to this marked hypertonicity; moreover conventional contrast agents are ionic in character. The newer contrast agents differ from conventional ones with decrease of osmolarity to approximately half. With lower osmolarity, th new contrast agents (Hexabrix of Mallinckrodt, Iopamidol (Isovue) of ER Squibb & Sons and Iohexol (Omnipaque) of Winthrop) are clearly attractive alternatives, barring their cost which is much greater than conventional agents. Nonionic contrast agents have reduced the toxicity of arteriography, myelography and intravenous urography, which allows more patients to be examined safely and painlessly. The absence of pain on injection enables the patient to lie perfectly still so that subtraction techniques are readily performed. During interventional type procedures, to verify the status of occlusion balloons etc., multiple injections to the same site can lead to capillary damage and complications. The nonionic contrast agents have almost eliminated this concern. Additional companies are coming out with non-ionic contrast agents so that we may see price reduction in the near future.

C. *Increasing Use of Digital X-Ray Imaging*

In conventional radiography, the image is detected on film and displayed on a lightbox, and in many cases the image is processed before display to provide better adaptation to human perception. In imaging modalities using film as a recording medium, the image information is in an analogue form, and digitalisation is required to convert it into a computer readable form before it can be processed. The amount of light transmitted, when recording done on film is illuminated, is measured and this information is then digitised by an analogue.digital converter and entered via an interface into the computer. In the computer, the image is stored as a set of picture elements or pixels, arranged in rows and columns, and image by image. Each pixel is assigned a grey scale value representing the measured physical quantity at the corresponding point in the image. In mathematical terms, the arrangement is most easily expressed as a grey value assay Gn (x,y) where x and y are spatial co-ordinates and n specifies the image number, which can depend on time, position, energy, etc. Digital image processing, in its basic form, consists of rearranging or mixing the grey values of the pixels, may be to store an image in a file i.e. to reduce it to a compressed coded form, or to adapt to the requirements of the observer during display.

There are two basic types of digital image processing to aid the radiologist in optimally inferring the unknown state of the imaged part of the human body from the set of images: (a) extraction of physiological parameters (or quantitative measurements) and (b) modification to another type of pictorial information. The extraction of functional physiological information from a series of images is known from radionuclide imaging which will be reviewed subsequently. Visual perception of image details can be improved by contrast enhancement which can be achieved either globally or locally, as a function of pixel level (X-ray exposure, CT number, relaxation time etc.), spatial frequency or temporal parameters and physics related parameters. Contrast as a function of pixel level is enhanced globally when ordinary brightness and contrast adjustments are made. For local contrast adjustments as a function of pixel level taking into consideration the surroundings alone, histogram modifications are employed. The histogram indicates the number of pixels, with brightness corresponding to each grey-scale level. The histogram is modified according to a prescribed curve, which may be in the form of a constant (the number of pixels for all grey scale levels is equal) or a hyperbola (compensating for the logarithmic response of the human eye). All picture elements are then transformed in such a way that they result in the prescribed histogram. The corresponding transformation can be calculated from the given values of the histogram of the primary image and the histogram aimed at. Although this manipulation is purely cosmetic in the sense of adding no new information but adapting the information content to the eye, the result is striking. Histogram hyperbolisation image enhancement procedure is applied only to a section of the image by interactively marking the part required. This zonal processing has the advantage of computation time. Often, specially in conventional radiographs, the pixel level is not a good specifier of an anatomical feature; the size or the spatial frequency contents of the feature may be better. In such cases contrast can be enhanced by spatial frequency filtration. 'Unsharp mask filtering' is one such technique which subtracts a weighted low-pass version of the input from the image itself. In Digital Subtraction Angiography (DSA), subtraction of images acquired before and after opacification of the vessels with a contrast medium is effected; the conspiquity of the contrast filled vessel is raised by subtracting the structures of the surroundings. Visualization of coronary arteries after injection of contrast medium is difficult because of the nearly simultaneously occurring opacification of the pulmonary and cardiac vasculature. To eliminate the effects of heart motion an integrated phase-matched subtraction technique is used in which each contrast image from a gated or high frame rate sequence is subtracted from the average of all available contrast-free phase-matched images. An inspection of the contrast passage history curves (Opacification of a vessel region as a function of time) of the left anterior descending coronary artery, aorta and pulmonary vein reveal poor temporal separation, so that remasking cannot cancel the pulmonary veins without subtracting coronary artery contrast. In addition since the cure-shapes are similar, techniques which selectively suppress a temporal frequency range tend to affect the coronary and pulmonary vessels equally. The algorithm for distinguishing pulmonary from coronary behaviour, calculates, for every pixel, the sum of squared deviations between the pass curve of the pixel and a reference region. In this way, a single parametric image is formed from the series of temporal images. Such computerised subtraction has enabled high quality angiography to be performed as a relatively

non-invasive routine examination, rather than as a difficult and sometimes risky complex procedure.

Having processed an image, the next logical step is digital image storage. To achieve this economically, in terms of both time and storage capacity, the number of bits of images with high information content has to be reduced. This can be done, without loss of image quality by transforming the image in an appropriate space where less extensive coding is required than in the original image space. Drawing on the experience obtained in telecommunication and data storage it is possible to transmit digitised medical images and other data without information loss via cables or fiberoptic links and to store them on optical discs, so that virtually instantaneous storage and retrieval of medical images via a central digital archive is already a practical possibility. One optical disc has a capacity of 10^{10} bits, so that a 'juke box' of discs would be sufficient for a year's image storage.

Digital image processing is in a state of continuous evolution. Two events in particular, viz.start of wide-spread clinical application of Magnetic Resonance Imaging (MRI) and the advent of filmless computed radiography, have stimulated increased activity. In addition hardware developments have enabled the implementation of computation intensive algorithms, such as large kernel filter operations with acceptable computation times at affordable costs. While processing methods for parametric images will be refined, increased efforts in the diagnostically oriented processing for supporting the clinician in assessing specific disease states or anatomical pathologies are expected.

D. Development of New Radiopharmaceuticals

The aim of nuclear medicine is to make a diagnosis with the aid of highly specific radiopharmaceuticals. This would require that these agents are very selective for the site of accumulation. Theoritically, the radiopharmacological behaviour of radiopharmaceuticals and their scintigraphic pattern of distribution in the body could, therefore, be indicative and specific for a disease. In practice, however many radiopharmaceuticals are not very selective as to where they accumulate.

Nuclear medicine began with the development of ^{131}I as a practical radiopharmaceutical and came to be practised widely with the development of ^{99m}Tc, and of cardio-nuclear medicine with the development of ^{201}TI. The recently developed ^{123}I labelled IMP is a very important new medicine facilitating cerebral blood flow imaging and along with ^{99m}TC-HM-PAO, which is most recent to arrive at the market, will probably give a strong impetus to further development of nuclear medicine.

Either the rotating gamma Camera Emission Computed Tomography (ECT) device, or the multidetector Single Photon Computerised Tomography (SPECT) device is utilised for examinations using IMP. As the sensitivity and resolution of the latter are particularly high, it can obtain more information than the rotating camera ECT device. With this new machine a new clinical perspective has been opened, as diagnosis can be performed not only by using static images, but also by tracking the change in IMP distribution in the brain after intravenous injection. SPECT techniques provide three dimensional data that are subsequently displayed as scintigraphic slices. This enables not only detection of the tumour more specifically in the body, but is also important for the determination of the tumour volume. With the use of radiolabelled antibodies, diagnostic testing in malignant disease has improved. Immunoscintigraphy has been used to image cancers, including gastrointestinal malignancies, melanoma, prostate carcinoma, liver carcinoma, breast carcinoma and genitourinary carcinomia.

Not until the past decade, has radionuclide imaging become a widely accepted and available technique for non-invasive cardiac evaluation. With this technique, both functional and myocardial perfusion studies can be performed routinely. The procedure of radionuclide cardio-angiogram (RNCA) is simple requiring only an intravenous injection of radionuclide and application of electrode to the patient's body for ECG monitoring. The risks to the patients are minimal and involve only those resulting from radiation decay. Recently the three-dimensional concentric display of cardiac muscle function and the new factor analysis technique have been introduced and they are opening up new horizons in functional analysis of organs. The latter technique extracts a characteristic pattern from a group of successively gathered images by statistical methods and displays a functional map of movement of the pattern.

Positron 'Emission Tomography (PET) provides quantitative three dimensional images of specific

biochemical, physiologic and pathophysiologic processes in the living human brain and several other organs of the body. Positrons are positively charged electrons that some, physicists say, travel backwards in time. When they meet their normal negatively charged counterparts, both disappear in a great flash of energy that positron tomography are designed to detect. Two so called 'annihilation' photons or rays are emitted at angle of 180°. The fundamental principle of PET is the localisation of the points of origin of the annihilation photons generated at the site where positron emitted from the injected tracer or radiolangied meets the real electron. The detectors are therefore designed to record coincident radiation i.e. photons that strike opposite detectors simultaneously. Much additional work will be required to extract a maximum amount of useful information from the application of PET technology; yet PET is the only existing in vivo technology now suitable for study of metabolic activities like neurochemical systems in the human brain.

E. Realtime and Doppler Ultra-Sound

An ultrasonic target is a surface that causes reflection of ultrasound when a wave front emitted as a narrow beam by ultrasound transducers containing piezo-electric crystals encounters an interface between two materials of different density and with different acoustic impedances. e.g. pericardium, myocardium, endocardium, etc. In case of echocardiography, reflected ultrasound echoes striking the crystal surface generate vibrations that are converted to electric impulses, amplified and processed. Electronic circuits measure the time delay between the emitted and received echo, and using the known speed of ultrasound in tissue, convert this time delay into the precise distance between transducer and tissue. The intensity of the reflected echoes is proportional to the density of the reflecting tissue, whereas an analysis of the frequency shift between the emitted and reflected ultrasound waves provides information on velocity. The distance and density information are used to generate unidimensional or two dimensional (2-D) images of the tissue; velocity data are used to study flow within cardiac structures.

In M-mode echocardiography, a unidimensional image is obtained in its usual presentation as a graph on television screen; the density (image brightness) of tissues and their position along a single stablike line are plotted on the vertical axis while the time history of the image sweeps horizontally across the screen. In 2-D scan by moving the narrow ultrasound beam across the target field (scanning), information is obtained on position and motion in a second dimension perpendicular to the ultrasound beam; the ultrasound beam thus examines an entire plane or cross section of the target object. the actual image consists of a series of adjacent M mode line displays in which the bright dots and lines are fused by the observer's eye to form an integrated picture. The beam scans the field so rapidly that very few changes can occur in field, during a single scan period. This scanning technique is called real-time B-mode scanning, or commonly, 2-D echocardiography in case of heart; changes within the cross section can be followed by repeating the scan even as frequently as every 17 msecs.

Whereas the cardiac structures and their motion are visualised with 2-D echocardiography, Doppler echocardiography studies the flow of blood within these structures. In the clinical application of the Doppler principle, ultrasound is emitted by a stationary transducer, the red blood cells act as moving reflectors, and the reflected ultrasound is recorded by the same or different transducer. In modern echoscanners, both imaging and Doppler measurement capabilities are often combined. In pulsed wave doppler, moderate to high velocities can be measured at selected locations within the circulation, whereas in continuous wave doppler, higher velocities can be measured and this ability is of particular importance in the evaluation of patients with valvular and congenital heart disease. To obtain better spatial orientation of flow within the cardiovascular system, real time colour flow mapping, a technique combining 2-D echo and pulsed doppler, has recently been introduced, and the velocity signals are converted into colour displays. To avoid the difficulties of transthoracic echocardiographic views in patients with obesity, emphysema or abnormal chest wall anatomy, transoesophageal echocardiography (TEE) with a combination of M-mode, 2-D and colour flow capabilities, offer not only less likelihood of images distortion, but also possibility of continuous recordings of cardiac activity for extended periods of time, because of the stability of the transducer position in the oesophagus. Qualitative and quantitative haemodynamic and anatomic information regarding valve defects and cardiac shunts especially in neonates and children with congenital defects are now available with these versatile diagnostic tools. Even prenatal diagnosis of structural heart disease is now a reality. In

fact truly useful information about hemodynamic events all over the body is now available.

To evaluate the abdomen and pelvis sonographically transabdominal (TA) has so far been the modality of choice but enhanced resolution afforded by the recently available transvaginal (TV) probe can replace the TA approach in future. TV probe besides imaging the endometrium in greater detail has contributed significantly to the identification and assessment of intrauterine and extrauterine gestation. Similarly intracavity sonography of the bladder and transrectal sonography can help in early detection and staging of bladder and prostate cancer with images superior to those obtained with conventional transpelvic approach. Even ultrasound has been found to be a simple, reliable, relatively non-expensive and non-hazardous intra-operative screening technique for examining the common bile duct during cholecystectomy and providing a reliable guide as to whether surgical exploration is indicated.

The potential of the state-of-the art of ultrasonography for providing comprehensive and accurate information about various anatomic structures, superficial and deep, moving and stationary and cystic and nodular is undergoing continued technological refinements and expertise. Use of this technique will be of great benefit in reducing the need for many expensive and hazardous diagnostic procedures and hence recommended as primary method for medical imaging. However it must be remembered that accuracy of diagnosis improves with increased experience, improved working methods, and versatile equipment system. It is true that the combination of a good sonographic image and an examiner with sufficient experience can yield a sensitivity and also a specificity that have no specific disadvantage when compared with computed tomography (CT).

F. Computed Tomography (CT)

CT is a specialised X-ray examination. Every CT scanner consists of (a) X-ray source (Tube and HT generator), (b) detector(s), (c) data processing and display facilities and (d) scanning gantry and patient support. The process consists of rotating an X-ray tube around the patient. X-rays pass through the patient and are captured by an array of detectors. Structures within the patient change the characteristics of the X-ray beam; thus the beam that reaches the detectors carries information about the internal anatomy of the patient. This information is assembled to form a recognisable image by high speed computers and displayed on a screen. Rotation of the X-ray tube ensures that samples are taken from many different angles and this makes the final picture much more accurate.

Now-a-days CT has become a routine procedure for examinations of the whole body, the abdominal and thoracic organs, and the extremities, as well as for examination of body structures with various aims and indications and of course many different detailed examinations of the brain and skull. CT scanning had also answered many of the problems associated with quantitative diagnostics, heart examinations, and all types of treatment planning and control for radiotherapy.

For the quality of a CT image, parameters like contrast discrimination, spatial resolution, fineness or thickness of the imaged layer, dose and exposure time for the individual layer, freedom from artifacts, freedom from noise, homogeneity and absolute accuracy of the calculated attenuation values are of particular importance. Some of these parameters change in direct ratio with each other, while others change in inverse ratio. Present day scanning methods do not yet yield the required high spatial resolution with simultaneously increased contrast determination. A higher basic image quality thus brings as corollary, differentiation into different scanning techniques for different applications. Partial scans or target scans offer a satisfactory solution to the problems of obtaining the highest possible resolution, which is generally only necessary for a limited part of the total body cross section. In partial scanning all detectors are directed towards a limited region of interest within the body and only this region is scanned. This procedure reduces X-ray exposure, and all detectors can be used to provide a high resolution image of the scanned region. Slide reconstruction however poses some problems since the beam passes through structures in the body lying outside the region of interest resulting in severe artifacts, if the data obtained are used without appropriate correction. The result of a partial scan is striking so far as the reconstructed region of interest is completely free of artifacts, whereas the surrounding field suffers from severe distortions. Partial scanning of this type will undoubtedly enable the spatial resolution in future scanner generations to be increased. Another future option could be the dual energy scan which enables absolute Houns-field values to be determined for the absorption in the tissue and offers the possi-

bility of distinguishing between types of tissue e.g. between benign and malignant tumours.

CT offers not only the possibility of series exposures, but also the possibility of simultaneous evaluation of localised variation in absorption as a function of time resulting from the passage of a contrast medium. Thus CT offers a new quantitative functions parameter. If suitable contrast media can be devised to cover not only the blood flow but also metabolic and a storage processes, CT may lead to another revolution in diagnostic radiology.

The fast universal scanners now available are already being used for certain routine heart examination. An exposure time in the region of 150m secs is required to render the heart virtually stationary. Hence in view of technical specialisation required, the question remains whether, such short exposure times should be realised in a universal scanner which might even be used for routine brain scans, or whether it will be dedicated for a specialised system. Improvements in the image quality, and a further reduction in the scan time will not only have consequences for the desired special examinations, particular advantages in haemorhaging and seriously ill patient can also be expected.

However in future the components of CT system will undergo specific development e.g. (a) in the X-ray tube particular attention will be paid to the thermic loadability and the particular shape of the focus(b) the detector arrangement in future scanners will undergo even further refinement than that known today, and (c) integration of processing facilities particularly for specific applications. Even though currently available CT systems have already reached a stage where they have become a permanent and indispensable part of the diagnostics, CT will undergo continued development and expansion over a number of years to come.

G. Magnetic Resonance Imaging (MRI)

The imaged obtained with MRI bears a superficial resemblance to crude CT images and the reconstruction methods used are virtually identical. However, the measurements from which they are derived do not depend on absorption or reflection of radiation applied from outside the body or the emission of radiation from radiopharmaceutical introduced in the body.

MRI is dependant on the fact that the hydrogen nuclei, plentiful in water and biological tissue lipids, behave as tiny magnets. Under ordinary circumstances these nuclei are randomly oriented; in the presence of a magnetic filed, they realign themselves along the force of the applied field generating a net magnetisation. If a pulse of radio frequency radiation is applied to the now aligned hydrogen nuclei, they began to precess or spin about the axis of the externally applied magnetic filed. The frequency of the precession is proportional to the strength of the applied magnetic field. As the precessing nuclei relax back to their equilibrium state, they emit radiofrequency radiation which may be detected with a tuned antenna and analysed. The time it takes for the excited nuclei to return to equilibrium may be described by two time constants or relaxation times: the spin-lattice time T1 the time required for the longitudinal component of the magnetisation vector to return to its equilibrium position, and T2, the spin-spin relaxation, the time required for the dephasing of precessional spins fo the excited nuclei; T2 also influences the decay of the nuclear signal emitted. T1 and T2 may differ in different tissues, they may also differ in the same tissue depending upon metabolic conditions and disease states.

An MRI scanner consists of the following components: computer, radioequipments (a transmitter, amplifier, transmitter-receiver coil, preamplifier, receiver, and a method for converting the analogue radio-signal into a digital form that can be processed by the computer to form a final image) data shortage, image display system, magnetic gradient, and of course, the magnet.

One of the controversial issues facing the wide spread clinical adoption of MRI, in spite of its resolution comparable to CT, reduced imaging time, rapid reconstruction, spectroscopic measurements and non-proton imaging, is the question as to what constitutes the optimal field strength of the magnet. The basic difference between high and low field strength systems is that generally only high field strength systems will be useful in nonproton imaging application (where atoms other than hydrogen atoms viz. phosphorus and sodium are resonated to produce the image) and spectroscopy (a non-invasive technique for measuring biochemical changes in tissue that signal the onset of disease long before other symptoms appear). As far as proton imaging is concerned, the better low field systems always seem to be able to match and, in some cases and for certain applications, exceed the performance capabilities of the higher field

strength systems, producing very high quality proton images within reasonable time frames.

Benefits of MRI Application

During the last five years or so, the following benefits have been derived in medical imaging with MRI applications, besides the fact that the patient is not exposed to ionising radiation:—

a) Visualisation of lesions with specific signals - MR signals coming from the region of interest are related to T1 or T2 time constant and proton density. T1 values of tumours tend to be of such quality that the signal level is low and they appear on the radiographic film: this is referred to as low intermediate signal levels. The T2 values of malignant tumours are prolonged and hence they give up signal for a longer period of time than adjacent normal tissues. Under this set of circumstances, they will appear quite bright compared to their surrounding tissue on T2 weighted pulsing sequences. Unfortunately considerable overlap takes place between normal and malignancy wherever inflammatory disease is superimposed. Nuclei with an odd number of protons must be present to receive a signal from any tissue. Calcified lesions are very poor in MR signals and hence they appear quite dark whereas tumours with a lot of protein, blood break-down products or other fatty lesions are generally quite bright on MR signals. Therefore when one couples the MR signal characteristics with the anatomic site and morphology of a lesion, relatively specific diagnosis become possible. In a clinical setting of a young individual who is high risk for AIDS, MRI may indicate the presence of the disease because signal specific lesions are encountered as long as six months prior to the blood test becoming positive for HIV virus.

b) Information concerning morphology - The lumen of the blood vessels are visualised as absence signal when blood flow is rapid: slower flows that are near the entry slice can be seen as a bright signal because the protons coming to the plane of section have not been magnetised previously and are able to give a high signal. Identification of blood vessels and the rate of blood flow is particularly helpful about skull base lesions and masses around the head and neck. Tumours that share the common anatomic sites can frequently be differentiated on the basis of their vascularity and MRI many a time eliminates the need for diagnostic angiography. With MRI, the differentiation of cystic and solid lesions is very much like that of CT; cystic lesions present as a homogenous signal on both T1 andT2 weighted pulsing sequences. Their degree of brightness will depend on the amount of protein or blood within the fluid. Mandibular lesions, sinus carcinomas, and other tumours involving the paranasal sinuses all can be better characterised with MRI than almost any other imaging modality.

c) Visualisation of new anatomic sites - MRI has solved one of the dilemmas of CT, and that is, imaging about the skull base. With a CT beam hardening artifacts, frequently, fine detail is impossible to discern. Although MRI does not visualise calcium as a positive signal, the cortex of bone can still be seen as an absence of signal; even blood flow and marrow spaces within the bone are visualised by variations of high signal for fatty marrow and intermediate signal for red marrow. Soft tissue adjacent to dense bone such as the cavernous sinus, the internal auditory canal, the medullary space of the mandible and other tubular bones can be carefully scrutinised with MRI. The better soft tissue contrast is also of considerable help in examination of the pelvis, spinal canal, mediastinal structures, and regions of thoracic inlet where artifacts from the shoulders frequently obscure CT imaging. In examination of the abdominal organs, the field of MRI almost coincides with that of CT. Although information content of the images is radically different, abnormalities in the structure of the liver can be clearly shown and it is possible to detect diffuse structural changes such as disturbances in copper metabolism (Wilson's disease), cirrhosis, steatosis etc. It has already been established that MRI can provide good images of the kidneys, urinary bladder, prostate and uterus. The rapid inherent movements of the heart during contraction lead to a loss of signal for heart structures during the relatively long imaging time. However ECG triggering has enabled the excitation pulse to be synchronised with the heart beat, yielding images of outstanding quality. In this procedure the MR pulse follows immediately after the R wave of the ECG or is delayed for specified time. The cardiac chambers, heart walls, papillary muscles and heart valves can be seen with a contrast and a spatial resolution unobtainable by any other method. The thickness of the heart wall can be assessed and ventricular thrombi or heart wall tumours can be imaged precisely. MRI allows a choice of sectional planes in the coronary and sagittal directions in addition to the usual axial image obtained with CT and this offers decisive advantages in the imaging of the

heart and neighboring large vessels. In addition to the acquisition of morphological information, these examinations are also of value in allowing assessment of functional parameters such as (a) absolute volume (end diastolic, end-systolic, and stroke volume), (b) ejection fraction, (c) cardiac out-put, (d) regional ejection fraction or contraction, (e) analysis of movements per sector. If information on energy metabolism becomes available in future by the imaging of a31 p spectrum of energy high phosphate, the MR could acquire decisive significance in the early detection of myocardial areas at risk of ischaemia.

d) Interventional procedures - MRI can be used for biopsy needle placement (using a non ferromagnetic needle), monitoring blood flow, and probably in the future, real time imaging with fast echo techniques.

e) Integrated research for physiologic data - Because the raw data of MRI is already digitised, it is a very easy and simple matter to store and manipulate this data in parallel with other imaging techniques such as PET scanning and CT. MRI can also be coupled with the digital images of angiography.

On the whole MRI is very expensive and it has been difficult to achieve high volume patient demand because of high cost. The methods of reducing the costs will include

(a) simplification of installation

(b) lower operating and maintenance costs, and

(c) lower equipment costs. The major sources of improvement in the cost in the past few years have centered around the issue of improving patient through-put and reducing the scan times. The factors include:—

(a) Rapid tuning and centre selection - In the early days manual scanner tuning by the technologists for changing the radio frequency (RF) unit until the maximum response signal was obtained after a laborious task of correcting, overcorrecting and so forth, for about 5-20 minutes. This is now computer-controlled and automatic so that tuning and centering takes between 40-70 seconds even using surface coil.

(b) Choosing short pulsing sequences-Most of the MR imaging using spin echo-techniques entails a 90° pulse followed by a 180° refocusing pulse of radio frequency. Following the second pulse there is delay while waiting for the protons to refocus. This prolongs the time before the next excitation (TR) and hence, the overall scan time Gradient echoes now provide a valuable alternative to T2 pulsing sequences because they can be performed in a very short time. In Gradient echoes the initial 90° pulse is reduced to a 10-30° pulse and is followed by refocusing from the gradient which is much faster and much more efficient, Scantimes in the neighbourhood of 11-20 seconds are easily obtained for single slice techniques. However, intracranial studies have not given as consistent results as gradient echo studies in other parts of the body.

(c) Well developed routines employing 'Q' series - As the radiologist become more familiar with the optimum pulsing sequences for specific regions or anatomy and firm routines are established, it becomes a relatively simple matter to have a group of pulsing sequences, computer-controlled, so that the examination proceeds in an orderly fashion (if the patient has not moved and no metal artifacts are present,) from pulsing sequence 1:2 and 2:3 etc. without operator intervention. This diminishes the delay in between pulsing sequences and greatly expedites the time of examination.

(d) Bunching of patients with the same diagnosis - patients can be scheduled in groups according to diagnosis and examination required to derive two-fold benefits (i) the examining couch and ancillary equipment i.e. surface coils and various paddings are usually left in place, (ii) the pulsing sequences that are loaded into the computer do not need to be changed, except the patient's identification. Usually five or more minutes can be saved under these circumstances.

(e) Department orientation and education - One cannot repeat too strongly the need for a total team approach to MRI with a co-operative spirit between receptionists, technologists, radiologists, secretarial support and every one having to do with providing patient services. By the time the patient on arrival at the scan centre has been thoroughly indoctrinated to the procedure by the receptionist, all considerations for the approaching scan have been reviewed and the radiologist has pulsing sequences preplanned, so that examination can proceed in an efficient fashion without any delaying pitfalls. Needless to say, the radiologist must know what he is looking for and what clinical question needs to be answered.

(f) Hard copy production and archiving - with double echoes, rapid scanning with gradient echoes, and a multitude of projections being performed in MRI, large number of images are being obtained. All of these images must be photographed, reviewed and archived in some fashion. Handling of all this data is going to require a vast rethinking of radiologic approaches to im-

age review. By using the Voice Rad System, which directly changes the spoken voice via a computer into a typewritten report on the left side of the corresponding dry silver photographs taken, within a minute or two, total dictating of the X-ray report can be completed. After the report is compiled and typed it is mailed to the respective physician. Unless specifically requested, the entire MRI examination is not photographed on film but is retained in an electronic state on the laser disc. The X-ray report is merely transferred from Voice Rad Computer to the laser disc so that there is no filling of an X-ray report. Both the images and MRI report can be recalled for viewing or filming at any time. To fully understand the MRI technology and use it effectively radiologists will need about a year and a half of training, although some diagnostic skills can be learnt in about three months. While MRI images look much like the images produced by the CT scanning, the technology that underlies those images is vastly different- the signals producing the image deliver an entirely different grey scale and the imaging factors that control this grey scale are greatly expanded. The radiologist unfamiliar with MR will see structures that look similar but not understand why something shows up or fails to show up and will have to learn how to select a pulse sequence appropriate for detecting the suspected disease. Training costs for MRI therefore looms as a major issue.

III Picture Archiving And Communication system (PACS)

An integrated imaging network combines and distributes the output from digital imaging systems such as CT, MRI, DSA and digital radiography for access by the radiologists from one or more centralised viewing stations. Such an imaging network is generally known under the name as PACS. For successful implementation of PACS, three conditions must be met (a) technical feasibility, (b) Compatibility with imaging equipment, and (c) integration in existing procedures,

(a) Technical feasibility: The main components of PACS are the archiving media, the network itself and the viewing stations. As an archiving medium Digital Optical Recording (DOR) has shown it to be reliable for recording video and audio information (Video disk and compact disk) and has proved to be a suitable medium for the storage of medical images. A DOR disk has an enormous capacity e.g. 10000 CT images, and is relatively cheap. Viewing stations are dedicated subsystems with the capability of displaying images with the high resolution required, and performing image-processing functions. The hardware components for these viewing stations are available from related application such as Computer Aided Design(CAD), whereas the software effort involved in implementing the required viewing functions is specific to the PACS application.

(b) Compatibility with imaging equipment standards are required for interfacing medical imaging with PACS,. Some manufacturers are committed to the principle that all their imaging equipment will eventually be able to connect with a PACS network via a standard interface. In order to permit implementation of a multivector PACS, such a commitment is needed from medical imaging industry as a whole.

(c) Integration in existing working procedures. PACS should be a logical evolution of existing procedures to enable the users to do their work in a most cost-effective, more efficient, and better way. Feedback from the users is crucial in the introduction of PACS, so that any changes required to achieve efficient functioning of the system can be made.

IV Making X-ray Devices Intelligent

In the field of X-ray apparatus, the automatic phototimer which controls the exposure process is probably the most simple example of machine intelligence. The memory short is a more sophisticated device which automatically sets the X-ray exposure condition (KV,mA) in accordance with the characteristics of the X-ray tube and the conditions of use in the hospital. The use of microprocessors to increase the automation of mechanical devices and diagnostic table has made the apparatus more intelligent. Control of the X-ray collimation mechanism with respect to film size and shooting distance, automatic film feeding, the control of subdivisional radiography positioning. and fine adjustment of the exposure factors are other examples of advancement in this direction. In the future, X-ray apparatus will probably be such that every transfer of signals between units will be carried out either or by light cables and only the power source will be connected to each unit.

V Conclusion

Recent developments in medical imaging are overwhelming. It is needless to emphasise that while endeavouring further refinements and techno-

logical advancements, one must strive to adapt the behaviour of the machines to the human operator in general, and to the medical human operator in the clinical routine work environment, instead of forcing the human operator to follow the technology driven interaction concepts of engineers. In other words, it is imperative in future to design appropriate display systems, realise consistent and simple interaction strategies, and design appropriate interactive elements.

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7. Present and Future Perspectives of Application and Utilisation of Modern Technology in Nuclear Medicine

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I Introduction:

Last three decades stood witness to a tremendous expansion of technology in all areas of human endevour. This all- embracing influence of advances in technology has made practice of modern medicine simple and at the same time, more exacting. Today, diagnosis of complicated medical problems is made easier with the help of a large array of methods based on different physical and biochemical principles. Nuclear medicine is a relatively new speciality which has grown to its present status through an appropriate blending of advances in radiopharmaceutical, electronic and computer sciences. As of today, the major role of nuclear medicine is in investigating and studying various disorders, while it also plays a minor role in treating selected diseases.

II Scope of Nuclear Medicine in Tissue Imaging

Organ or tissue imaging is currently one of the most important diagnostic methods in medical practice. This can be achieved in various ways such as conventional X-ray radiographs, computerised X-ray tomographs, ultrasonographs, radionuclide scintigraphs and nuclear magnetic resonance image. Radionuclide scintigraphy and its modified versions like Single Photon Emission Tomography (SPECT) and Positron Emission Tomography (PET) provide information mainly regarding the functional aspects of organs and tissues. Information regarding the gross morphology or structure of the organs is considered a bonus to the main objective of functional evaluation. Thus radionuclide scintigraphy is essentially a functional imaging. The emphasis of other modes of imaging mentioned earlier is on gross structure of morphology. Hence radionuclide scintigraphy is to be considered as a complimentary modality, not a competitive one, to other modes of imaging while assigning its role in the diagnostic processes. As has been mentioned earlier, the most important aspect of nuclear medicine in relation to medical sciences in general and the clinical practice in particular is its ability to give exquisite functional information about organs or tissues in the body. Since functional disturbances often preceed gross structural alternations in the organs, nuclear medicine techniques are useful as early warning devices. Also while recovering from the disease process, many a time, function recovery takes place before structure recovery. Thus, nuclear medicine procedures serve to monitor response even during the early phase after the specific therapeutic intervention is carried out. All this is achieved in relatively much simpler and safer way, with no more radiation (in fact much less) risk that what is incurred while undergoing comparable radiological procedures.

Radiopharmaceuticals, nuclear instruments and nuclear medicine specialist form the three corner stones of the operational triangle of nuclear medicine. The centre of the triangle is, of course, the patient. The nuclear medicine specialist has to choose the most appropriate radiopharmaceutical, nuclear instrument and the particular technique to provide the best and cost effective solution to the problem posed by the patient. Therefore, it is important that the nuclear medicine specialist must have adequate knowledge of radiation physics and chemistry, adequate training in operational aspects of nuclear instruments, in addition to a thorough understanding about the pathology and pathophysiology of disease processes.

III Radiopharmaceuticals

Since the time of George Hevesey who was awarded Nobel prize for his pioneering work in the application of tracer principle to study human physiology, a lot of advance has been made in the field of radiopharmaceuticals. Refinements in radiopharmaceuticals-radioactive

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chemical agents-have reached such a stage that it is possible to precisely target these agents to various areas of brain in order to get a map of different functional groups of neurons associated with seeing, hearing, reading, recalling etc.

The most common radioactive agent in today's clinical practice is Technetium-99m (Tc-99m)- an artificially produced element. In nuclear medicine laboratories Tc-99m is obtained as a decay product of Molybdenum-99 (Mo-99) which is produced in atomic reactors. In India, Bhabha Atomic Research Centre, Trombay, Bombay, produces enough Mo-99 for nuclear medical applications in the country. Mo-99 and Tc-99m which exist together are separated by suitable chemical or physical processes in the laboratory. Tc-99m is used as a radionuclide to label other chemical agents for diagnostic procedures. Tc-99m is considered as an ideal radionuclide for scintigraphic studies because it possesses matching physical properties with the most commonly used imaging instrument called Gamma Camera. The various radiopharmaceuticals used currently for scintigraphic studies of organs and tissues are listed in Table 1.

Positron labelled radiopharmaceuticals offer great promise for the future. Positron emission lends far greater accuracy in detecting their location within the body and in quantitating their concentration in the tissues. Positron emitters such as carbon-11, nitrogen-13, and oxygen-15, being elements in important biomolecules such as sugars, proteins and lipids, can be easily tagged to glucose, aminoacids and fatty acids. These radiolobelled metabolic substrates have been found very useful radiopharmaceuticals in the metabolic mapping of brain and heart and have been found capable of providing such valuable informations hitherto not possible by any other existing method. In brain, it has become possible to localise areas of brain subserving various motor and sensory functions. By tagging positron emitters to various neurotransmitters like dopamine and serotonin, it will be possible to study various brain disorders characterised by abnormalities in neurotransmitter release and action. Such methods are expected to provide windows (in the brain) through which one can get glimpses of the mind in health and disease.

IV Nuclear Instruments

There are a wide variety of nuclear instruments in today's nuclear medical practice. They include radioactive counters, both for counting radioactivity within (in-vivo) and outside (in-vitro) the body. In-vivo counters include thyroid uptake probes, renogram machines, nuclear stethoscope used for cardiac function measurement and multiprobe cerebrographs for measuring regional cerebral blood flow. In-vitro counters are used for counting radioactivity in samples like blood, urine, feces, and such other biological material; they are of two types, gamma counters and beta counters depending upon whether they are used to count gamma radiation or beta radiation. Such counters are mainly used in one of the most important measurements in medicine and biology i.e. radioimmunoassay- a technique by which substances of the order of few picogrammed and nanogrames are measured with extreme accuracy. Radioimmunoassay has revolutionised the practice of medicine in areas like endocrinology, use and abuse of drugs, and in the areas where measurement of bioactive amines and polypeptides are important for the study of diseases.

Instruments which are capable of providing the map of distribution of radioactivity within the organs or tissues are called Imaging instruments. Radioisotope rectilinear scanners and gamma cameras, are the two important imaging instruments although the former is becoming absolete as an imaging instrument. Among the gamma cameras, the Anger type of gamma camera is the most popular one which is considered the work horse of imaging in current nuclear medical practice. It is capable of providing atatic and dynamic images of almost any organ or tissue in the body using appropriate radiopharmaceuticals. Conventional gamma camera images are essentially two dimensional images of radioactivity distributed in three dimensions in the body. Like any other planar images, these images suffer from disadvantages of superpositioning and interference from radioactivity arising from different planes in the organ. Tomographic images are free from such drawbacks and are provided by Single Photon Emission Computerised Tomography (SPECT) and Positron Emission Tomography (PET) Cameras.

SPECT imaging is increasingly being applied to cardiac and brain imaging wherein tomographic slices of cardiac and brain images in different planes are possible. With the development of Tc-99m labelled radiopharmaceuticals SPECT imaging of heart and brain should become cost effective in the near future.

PET imaging is still in the realm of research applications. It is already being evaluated in

cardiological disorders such as coronary artery disease and other cardiomyopathies, and in neurological disorders such as Alzhiemer's disease and other forms of senile dementia and seizure disorders. It is also finding potentially useful applications in neuropsychiatric disorders like schizophrenia and manic depressive psychosis. PET imaging is expected to play a greater role in the understanding of various metabolic functions and psychopharmacological responses of the brain which can not be obtained using any other method. It may be the nuclear medical study of the future, if the findings continue to be as promising as they are today.

The story of today's nuclear instrumentation is most incomplete without mentioning the role of computers along with appropriate application programmes available in soft ware. With the use of computers, it has become possible to process and manipulate the basic data to display them in an easy-to-comprehend manner, and interpret to provide meaningful information.

V *Clinical Applications*

It is not possible to outline all the current clinical applications of nuclear medicine techniques in a short article. The following are some of the most commonly applied methods in clinical practice.

1. Nuclear Cardiology

Radionuclide studies of cardiac function today is an integral part of non-invasive diagnostic techniques in cardiology, the others being, electrocardiography and echocardiography. When the heart is considered essentially as a pump,. the myocardium forms the walls of the pump and blood in the ventricles forms the contents. Heart function can thus be studied either by myocardial imaging or by blood pool imaging.

Radionuclide Cardiac Studies

Myocardial Scintigraphy	Blood Pool Scintigraphy
1. T1-201 Perfusion Scintigraphy	1. First pass ventriculography
2. Infarct avid scintigraphy	2. Equilibrium gated scintigraphy
a. Tc-99m Pyrophosphate scintigraphy	
b. In-III labelled Anti-myosin antibody scintigraphy	
3. Metabolic scintigraphy C-11 palmitate imaging F-18 Deoxyglucose imaging N-13-Ammonia blood flow imaging	

Among all types of heart diseases such as coronary heart disease, valvular heart diseases, congenital heart disease, and different forms of cardiomyopathies, it is the study of various aspects of coronary artery disease that has been found most rewarding. Using some of the methods outlined above, the presence and the extent of coronary artery disease can be accurately evaluated. The effects of various interventions like drugs, angioplasty and coronary bypass surgery can be objectively assessed. For the detection and evaluation of coronary artery disease, radionuclide testing combined with exercise is found to be a better method than the other two non-invasive methods. The role of radionuclide methods in the study of valvular heart diseases and congenital heart diseases is limited and is mainly to supplement information obtained with echocardiography.

Metabolic imaging of myocardium using positron-labelled metabolic substrates like C-11 Palmitate and F-18- deoxyglucose appears to hold great promise in future. Even before structural and functional disturbances set in, the disease process can be identified through the detection of metabolic disturbances, biochemical aberrations which are the first to occur in disease. Therapeutic manoeuvres, designed to arrest the disease at its onset will thus be possible, fulfilling a dream in curative medical practice.

2. Radionuclide methods in Nephrology and Urology

Comprehensive assessment of kidney functions such as blood flow, urine formation and its drainage in the upper as well as lower urinary tracts is possible today using appropriate radiopharmaceuticals and suitable techniques. Radionuclide methods offer the opportunity to study individual kidney functions. This is important in nephrological practice because many diseases affect the kidneys asymmetrically and unilaterally. Because of the extreme safety, simplicity and accuracy of results in these methods, they are found highly suitable in children and infants. For the same reasons, they are preferred when repeated studies are necessary, as in renal transplant patients.

While ultrasonography and computerised X-ray tomography can provide excellent morpho-

logical information of the kidneys and urinary tract, radionuclide investigations can give exquisite functional information. In clinical practice these investigations have to used in a complimentary fashion so as to make them cost-effective.

3. Radionuclide method in oncology

The thrust area of radionuclide applications in oncology is in targetting radiopharmaceuticals to the tumor tissue through immunological methods. Availability of tissue specific radiolabelled monoclonal antibodies render tumor detection quite in the realm of practical medicine. Certain types of renal, hepatic and ovarian tumors have already been studied by immunoscintigraphy. Labelling of monoclonal antibodies with radionuclides having optimum imaging yield without compromising the immunological specificity of the antibodies needs meticulous attention to details and exacting procedures. Research and development in this direction hold greater promise for the future in cancer detection and treatment.

4. Radionuclide methods in gastro-enterology

Functional disturbances of esophageal, and gastric motility can be investigated with a high degree of sensitivity and accuracy. Measurement of esophageal transit time and gastric emptying time is found to be better than those using conventional radiological or biochemical means. Presence of gastroesophageal reflux, or duodenogastric reflux can be detected and quantitated with considerable simplicity and safety using radionuclide techniques. Localisation of sites of gastrointestinal bleeding using radionuclides, prior to selective angiography and surgery, is a routine procedure in many centres.

5. Therapeutic applications of radionuclides-nuclear medicine in therapy

As was mentioned in the beginning, application of open sources of radionuclides for treatment is limited to a few selected disorders. The limitation is in the tissue specificity of radiopharmaceuticals available today.

Iodine-131 has excellent tissue- ablative characteristics due to its emissions, and half life. Given as Iodide, I-131 concentrates in functioning thyroid tissue and this property is used to treat hyperactive thyroid glands and certain types of thyroid cancer. This mode of therapy is a well recognised treatment all over the world. When I-131 is labelled to meta-iodo-benzyl guanidine (MIBG), it is selectively concentrated by hyperfunctioning adrenal medulla in pheochromocytoma. Pheochromocytomas and neuroblastomas which are not amenable to surgery are effectively treated by I-131 MIBG.

Phosphorus-32, a pure beta emitting radioisotope of phosphorus is used for treatment of polycythemia rubra vera and certain metastatic malignant lesions affecting the bones such a prostatic cancer and breast carcinoma. It has been shown to alleviate disabling bone pains and improve the quality of life of the patient.

The highlight of nuclear medicine methods is in its extreme simplicity and safety giving it universal application. It is capable of providing valuable functional information about organs and tissue in a noninvasive way. It would appear that nuclear instrumentation has reached its pinnacle of perfection; the future of nuclear medicine lies in the development of radiopharmaceuticals which could be targetted to any tissue or organs in the body with high degree of selectivity. Labelled metabolic substrates and monoclonal antibodies are among the torch bearers in this direction.

VI Analytical Aspects of Nuclear Methods in Medicine

There are a few radio-nuclear techniques which have very limited, but specific roles in medical research, the main role being analytical in nature. These include whole body counting of radioactivity, neutron activation analysis and radiometric assays. These methods do not generally require administration of radionuclides to patients or human subjects. Radioimmunoassay, although having an analytical role, is quite different from the others in that it has a very wide and extensive application in medicine.

1. Radioimmunoassay (RIA)

Radioimmunoassay is used to measure very low concentrations of analytes. This method is based on the principle of saturation analysis, The antigen (the analyte to be measured) is in excess of the antibody (the reagent). The antigen will be present in two forms, the unlabelled one (with known concentration used for preparing standards or in the sample to be measured) and the radiolabelled one which is used as the tracer. When the antibody and the radiolabelled tracer

are added to the sample containing the antigen and equillibrated, the amount of antibody bound or free tracer will be a function of concentration of the antigen. From this known relationship, it is possible construct a standard curve from which the concentration of antigen in the unknown (test) samples can be determined. Radioimmunoassays which have been of considerable diagnostic importance include those of Australia antigen, the thyroid hormones - triiodothyronine (T_3), tetraiodothyronine (T_4) and thyroid stimulating hormone (TSH), human chorionic gonadotrophin(HCG), follicle stimulating hormone(FSH), prolactin, digoxin, cortisol, testosterone and gastrin. Insulin, growth hormone, angiotensin, adrenocorticotrophic hormone (ACTH) and others are useful in understanding the pathophysiology of disease.

With the development of more sensitive assays like enzyme linked immunosorbant assay (ELISA), the role of RIA has been gradually on the wane.

2. Radiometric analysis in Radiomicrobiology

Radiometric detection of bacterial metabolism is based on the principle that bacterial action on C_{14} labelled substrates produces measurable amount of C_{14} carbon dioxide. Detection of bacteremia was the first clinical application of radiometric assay system. There is overwhelming evidence indicating that radiometric method is more sensitive than routine methods for detecting bacteremia in general. Being faster than the routine methods the radiometric method permits earlier adjustment of antibiotic therapy and therefore plays an important role in the management of patients with serious infections. Today the radiometric method is the procedure of choice for detecting bacteremia in more than 900 hospitals in USA. Detection of urinary tract infections, and testing of sterility of compounds are other applications of radiometric assay.

3. Neutron activation analysis

Development of in-vivo neutron activation analysis gave rise to an important approach to the analysis of elemental composition of human being. By means of total body neutron activation analysis, calcium, phosphorus, sodium, chlorine, nitrogen and cadmium have been accurately measured.

Total body neutron activation analysis (TBNAA) systems designed for in-vivo studies generate a moderated beam of fast neutrons to the total body of the subject. Neutron capture by atoms of the target elements creates unstable radionuclides that revert to a stable state by the emission of one of more gamma rays of characteristic energy. These energy levels identify the element and the amount of radioactivity produced is proportional to its abundance. Radiation from the subject is measured in a highly shielded facility and standard gammaspectroscopic analysis is applied.

Invitro Neutron activation analysis of body tissues like biopsy specimens, hair, nails, etc, for determining the quantity of trace elements have been applied in medical research and in medicolegal studies.

4. Whole body counting

This is an in vivo measurement technique carried out by whole body counters which are designed to measure the total amount of radioactivity in the body. However, there is no attempt at localisation of the activity distribution. They are used for studying the retention, turnover and clearance rates with such radionuclides as Co-60, and Co-57 labelled to Vit. B-12, Na-24, K-42, Ca-47 and Fe-59. The whole body counters are designed in such a way that very small quantities (often less than 1 microcurie) can be detected and measured accurately. Another important application of whole body counting is the measurement of naturally occuring Potassium-40 which can be used to estimate total body potassium content.

Metabolic balance studies in health and disease can be conveniently carried out by whole body counting measurements. These include protein, carbohydrate, fatty acid and mineral metabolism.

Different radionuclides can enter the normal human subject in radioactive fall out as a result of nuclear accidents or incidents. Detection and measurement of such radionuclides can be efficiently and accurately carried out. High counting sensitivity is essential in such measurements.

Table 1: Some of the Commonly Used Radiopharmaceuticals and Their Current Uses

Radionuclide	Chemical Agent or Biological Material	Radio pharmaceutical	Uses
Tc-99m	Pertechnetate	Tc-99m Pertechnetate	Brain scan, Gastro intestinal studies. First pass blood flow images of organs.
Rc-99m	Phytate, Sulphur colloid	Tc-99m Phytate Tc-99m Sulphur colloid	Reticuloendothelial System scanning
Tc-99m	Diethylene Triamine Penta acetic acid (DTPA) Glucoheptonate (GH) Dimercapto Succinic acid (DMSA)	Tc-99m DTPA Tc-99m GH Tc-99m DMSA	Kidney scanning
Tc-99m	Human serum Albumin (HSA) Red blood cells	Tc-99m HSA Tc-99m RBC	Heart studies (Ventriculography)
Tc-99m	Phosphates	Tc-99m Phosphates	Bone scanning
Tc-99m	Microspheres	Tc-99m Microspheres	lung scanning blood flow studies
Tc-99m	Aerosols	Tc-99m	Lung Scanning
Iodine-131	Sodium Iodide (NaI)	I-131 NaI	Thyroid studies
Thallium-201	Thallium Chloride	T1-201 Thallium Chloride	Heart studies
Xenon-133	Xenon gas or in solution	Xe-133 gas or in solution	Regional cerebral studies, lung studies

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Three-Dimensional CT

A major drawback of conventional CT is that, clinicians have to figure out how to synthesise a series of flat two dimensional images. Three dimensional computed tomography (3D - CT) incorporates new software and advanced computer graphic capabilities to bring new insight into body structure and function, and also improve diagnosis and patient management. The three-dimensional CT images are provided within minutes of a CT scan. The operator can move the images in many ways. rotating the anatomy, shifting angles, or selectively removing structures.

The 3-D scanner can be set up, by adding some software to the existing CT machine; it does not increase radiation exposure for the patient. Radiologists are already using 3D-CT to help guide surgeons with intricate craniofacial reconstructions, for assessing the hip and pelvis, to make more comfortable prosthetics, and several other applications.

Ref: Hospimedica, 1987 Vol.V, No.3, pp 13

8. *Radiology — The Expanding Field*

William N. Hanafee, M.D.

Nowhere in the medical profession today can one find such an explosive growth of new technologies as exist in the field of radiology. The clarity of our present day images makes one feel somewhat uncomfortable as we reflect on the tenuous data that we had to utilize in the past for life-determining decisions.

With the improvements we have seen in computed tomography (CT), magnetic resonance imaging (MRI), positron-emission tomography (PET) scanning, real-time and Doppler ultrasound, and interventional radiology, whole new "areas of expertise" become apparent in each modality. For example, interventional radiology has become a field in itself with specific application in neuroradiology, abdominal intervention, genitourology, and in a multitude of vascular procedures. The same can be said for applications of ultrasound, MRI, and so forth.

I find it difficult to constrain myself to a reasonable number of pages for this issue because so many important things have to be left out. Having talked to the editors of Radiology, American Journal of Roentgenology, and various other journals, I find my frustrations are not a singular experience. Many of these new techniques have been slow in penetration because of financial considerations. This problem deserves our first attention.

Cost reduction

We all have to sacrifice quality for cost reduction but maybe there is another solution to high equipment costs. Increased patient throughput and prolongation of working hours can be achieved without sacrificing our high standards. Two important studies have been performed that illustrate this point.

Evans[1] found that the average number of hours scanners worked in the United States in 1987 was 12.7 hours per day and 5.4 days per work week. DiMonda,[2] from the office of Technical assessment of the American Hospital Association, surveyed the operating costs of MRI units during 1985-1986 and suggested an average cost of approximately US$700,000 per year to operate midfield-strength magnets. If one divides the number of hours per year that are worked into the average costs per year, the figure comes out to be approximately US$216 per hour to operate a midfield-strength unit, which includes equipment depreciation, capital costs, consumable supplies, etc.

If one can increase the number of patients examined per hour to the range of two or even three patients, the cost of MRI examinations begins to approach that of routine film studies. Some simple things to improve patient throughput are through-scheduling to "bunch patients" who are to have the same region of the body examined with the same pulsing sequences. Another assist has been provided by some manufacturers that allow a series to two to three pulsing sequences to continue in sequence without interruption for returning. Major breakthroughs in throughput will occur when we are able to go to such things as gradient echoes, double echoes that provide true T_1 and true T_2, and some three-dimensional data acquisition techniques.

Our clinical colleagues will require a great deal of reeducation when we begin to photograph only the pertinent images of different pulsing sequences. This must happen because data will be acquired in such volumes with faster scanning techniques so one cannot possibly photograph every frame of a scan. The radiologist will photograph the pertinent images while he is reading with some type of instant "camera." The final images will be ready with the report.

Expanding imaging modalities

Before starting, I wish to reiterate that due care must still be given to the immense role that plain films perform in medical diagnosis. Neverthe-

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less, these new technical developments must be recognized and fully utilized or other clinicians will step in to fill the gap. Many of the modalities will require us to learn vastly expanded chemistry, physiology, and a new clinical expertise that are not normally a part of our armamentarium. A partial list of technical advances is as follows:

1. Contrast agents both for general diagnostic work and MRI
2. High resolution real-time ultrasound and Doppler flow
3. Ultrasound with in-vivo probes
4. Interventional procedures
5. High resolution nuclear scanning and PET scanning
6. MRI applications with new pulsing sequences
7. Computer-based radiology operations

Some of the uses of ultrasound and in particular the transvaginal probe are described nicely in an article in this issue of Hospimedica, by Dr. Perrella. The Doppler flow greatly assists in the evaluation of arteriosclerotic lesions about the neck and to some extent in the lower extremities.

Nonionic contrast agents have reduced the toxicity of arteriography, myelography, and intravenous urography, which permits more patients to be examined safely and painlessly. The lack of pain on injection enables the patient to lie perfectly still so that subtraction techniques are readily performed. When interventional-type procedures are being performed, multiple injections have to be made to verify the status of occlusion balloons, etc. With ionic contrast agents, multiple injection into the same site can lead to capillary damage and complications. The nonionic contrast agents have largely eliminated this concern. At the present time, cost has been a consideration, preventing a more wide-spread use of nonionic contrast agents for the more routine type of diagnostic procedures. additional companies are coming on-line with nonionic contrast agents so that soon we may see a price reduction. Many of these topics are now beautifully covered by contributors to this edition.

Gadolinium, which has been used for MRI of the brain quite extensively in Europe, has now been accepted in the United States. It was approved by the U. S. Food and Drug Administration (FDA) on July 1, 1988 and is already being used extensively. The principal advantage of gadolinium is being able to detect a break-down of the blood/brain barrier, which allows it to become concentrated in tumors. The gadolinium shortens the T_1 value so that signal is enhanced from lesions that have damaged capillaries. It has shown some promise in regions other than the brain so that its full potential will now be exploited by the multitude of investigators throughout the United States. Used judiciously it can be extremely helpful in diagnostic problem cases. Whether gadolinium will be able to differentiate between radiation changes and recurrent tumor remains to be seen. In one or two instances it has been very helpful to us. There may well be other contrast agents for MRI on the horizon such as iron compounds or other ferromagnetic materials that will play a major role in liver-spleen diagnoses.

Intervention has expanded far beyond that of the initial success with arterial-dilatations. Modern neurosurgery and head and neck surgery would be lost without the availability of preoperative embolization and vascular control that is possible by modern techniques. Some of these techniques are outlined in this issue by the article by Drs. Jabour, Vinuela, et al.

Nuclear and PET Scanning

Cyclotron technology is changing about as rapidly as some of our ultrasonic equipment. The cyclotrons that formerly required an entire building have been reduced to efficient operations that occupy a small room; even as these units are being installed the research has achieved desktop cyclotrons that operate in an extremely efficient fashion. Undoubtedly the major uses of nuclear scanning will be directed to physiology studies and tagged chemistry of a magnitude that we did not dream possible. One can easily imagine how nuclear scanning will be used to study the efficacy of drugs by watching the site of interest for metabolic activity. If a region is to be stimulated then one would see increased metabolism or if one is to be suppressed, then activity would diminish. Tagging of metabolites will be a rather simple matter once more agents become available.

MRI applications

Since 1984 we have had a virtual explosion of the application of MRI in head and neck lesions. Some of the most important benefits of MRI are listed as follows:

1. Visualization of lesions with specific signal
2. Information concerning morphology
3. Visualization of new anatomic sites
4. Assist in interventional procedures

5. Integrated research for physiologic data
6. Cost of medical care reduction

In many patients, two or more of the aforementioned applications of MRI occur simultaneously, but they have varying degrees of implication in patient management.

Lesions with specific signals: The amount of MR signal coming from the region of interest is related to three things: T_1 -time constant, T_2 -time constant; and proton density. In very general terms the T_1 values of tumors tend to be of such quality that the signal level is low and they appear on the radiograph film. This is referred to as low to intermediate signal levels. The T_2 values of malignant tumors are prolonged and hence they give up signal for a longer period of time than adjacent normal tissues. Under this set of circumstances they will appear quite bright compared to their surrounding tissues on T_2 -weighted pulsing sequences. Unfortunately there is considerable overlap between normal and malignancy whenever inflammatory disease is superimposed.

Nuclei with an odd number of protons must be present to receive a signal from any tissue. Calcified lesions are made up of atoms that are very poor in MR signal and hence they appear quite dark. On the other hand tumors with a lot of protein, blood break-down products, or other fatty lesions are generally quite bright on MR signals.

When one couples the MR signal characteristics with the anatomic site and morphology of a lesion, relatively specific diagnoses become possible. For example when sees circular, sharply outlined homogeneously bright signal regions on a T_1 -weighted image of the parotid glands, this would indicate multiple cysts. In a clinical setting of a young individual who is high risk for AIDS, MRI may indicate the presence of the disease even before blood titers become positive of HIV virus. Soms[3] reports that he has encountered these signal-specific lesions as long as six months prior to the blood test becoming positive.

Information concerning morphology. One of the easiest things to accomplish with MRI is to recognize blood vessels by low voids. During the MRI experiment, protons that have been "stimulated" flow out of the section and therefore do not give a signal in the plane of section. The lumen of the blood vessel are visualized as absence signals when flow is rapid. Slower flows that are near the entry slice can be seen as a bright signal because the protons coming into the plane of section have not been magnetized previously and are able to give a high signal.

Identification of bloods vessels and the rate of blood flow is particularly helpful about skull base lesions and masses around the head and neck. Tumors that share the same common anatomic sites can frequently be differentiated on the basis of their vascularity. For example, glomus jugulare tumors will closely simulate neuromas arising around the jugular fossa. Neuromas may have one of two fairly significantly-sized blood vessels, but they do not begin to approach the vascularity that one sees with glomus jugulare tumors. A similar statement can be made regarding juvenile angiofibromas, which show numerous large blood vessels throughout the tumor masses. As a matter of fact these are so striking that a specific diagnosis can be made. MRI eliminates the need for diagnostic angiography.

With MRI, the differentiation of cystic and solid lesions is very much like that of CT; cystic lesions present as a homogeneous signal on both T_1 and T_2 weighted pulsing sequences. Their degree of brightness will depend on the amount of protein of blood within the fluid. If the fluid is merely straw colored, it will act very much like cerebral spinal fluid and be of low signal on T_1 and become brighter on T_2. High protein fluids, mucous, and previous bleeding into the cyst will all produce varying degrees of high signal on both T_1 and T_2. This differentiation can be extremely helpful when one is trying to identify solid elements within cystic lesions. Mandibular lesions, sinus carcinomas, and other tumors involving the paranasal sinuses can be better characterized with MRI than almost any other imaging modalities.

Visualization of new anatomic sites. MRI has solved one of the dilemmas of CT and that is imaging about the skull base. With a CT beam, hardening artifacts frequently make fine detail impossible to discern. Although MRI does not visualize calcium as a positive signal, the cortex of bone can still be seen as an absence of signal; even blood flow and marrow spaces within the bone are visualized by variations of high signal for fatty marrow and intermediate signal for red marrow. Blood flow within bone follows the same signal patterns as blood flow in other regions of the body, with rapid flow usually being demonstrated as flow voids. At times the negative shadow of cortical bone and the flow voids of

bloods vessels can be confusing. This problem can be readily overcome if gradient echoes are added to the pulsing sequence, which characteristically changes any flowing blood to bright signal.

Most importantly, MRI enables one to carefully scrutinize soft tissue adjacent to dense bone such as the cavernous sinus, the internal auditory canal, the medullary space of mandible and other tubular bones. The better soft tissue contrast is also of considerable help in examination of the pelvis, spinal canal, medistinal structures, and regions of the thoracic inlet where artifacts from the shoulders frequently obscure CT imaging.

When examining the cavernous sinus, T_1 pulsing sequences are usually the examination of choice for better anatomic detail. The cavernous sinus is frequently quite bright on T_2 and detail is obscure. Extensions of lesions into the central nervous system require T_2 -weighted pulsing sequences for identification.

Interventional procedures. In addition to anatomic localization in a three dimensional fashion, MRI can be used for biopsy needle placement, monitoring blood flow and probably, in the future, real-time imaging with fast echo techniques. The beauty of MRI is that the operators do not have to worry about being exposed to ionizing radiation.

Lufkin et al use a nonferromagnetic needle for aspiration cytology diagnosis.[4] This needle can be placed in regions that are beyond the palpating fingers of the cytologist and can even be directed to body cavities adjacent to the skull base. Our needle has been adapted to stereotaxic work for intracranial interventional procedures.[5]

Integrated research for physiologic data. Because the raw data of MRI is already digitized, it is a very simple matter to store and manipulate this data in parallel with other imaging techniques such as PET scanning and CT. MRI can also be coupled with the digital images of angiography. The neuroradiology team at UCLA has written a rather simple program to be used on desk top computers, which enables one to view simultaneously on a monitoring screen the sections of MRI, PET scanning. [6] They have even arranged the data so that with a joy stick one can point to an anatomic structure in one imaging modality and the other imaging modalities will automatically adjust to focus on the same anatomic site. This can be extremely helpful by developing a three-dimensional picture of what vessels would be encountered with a needle placement and what regions of metabolically-active tissue would be encountered along the pathway.

Cost of medical care reduction. Surprisingly, much of this digitization offers the possibility of actually reducing the cost of medical care rather than building up an "expensive research toy." After some experience one can predict which areas will be metabolically-active and which blood vessels are located along surgical or biopsy pathways. The desktop computers are already available for other routine work and can be utilized at minimal expense.

In conclusion, we hope that this issue of Hospimedica will serve to stimulate innovative thinking on how to improve patient care at reduced cost. Although the expansion of radiology at times may seem overwhelming, we can rest assured that our future is quite exciting because a subspeciality of medicine such as ours will definitely attract the most inquisitive minds and capable physicians. We must all keep open minds and not resist the explosive nature of our changing speciality, or other disciplines will surely rise and take over the challenge.

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9. X-ray Image Intensifiers

Lower radiation exposure, better images, easier documentation

*K. Bartholmess**

The instrument known as an image intensifier in radiology is, in the strict sense, an electronic amplifier tube but the term generally implies the complete unit comprising tube, casing and auxiliaries. It is employed in fluoroscopy for the purpose of greatly enhancing the brightness of the normal fluorimetric image and thus reducing radiation dose to the patient on the same scale. The intensified image permits better visual recognition of details by the examiner and saves him having to go through the full process of visual adaptation before commencing with the examination. Modern image intensifiers and closed-circuit television technology at today's level coupled with the capabilities of digital data storage leave hardly anything to be desired by surgeons in visualization techniques.

X-ray image intensifier systems are visibly distinguished by a C-arm mounted together with the other components on a wheeled base. There are also permanently installed C-arm systems suspended from an overhead support, clamped between floor and ceiling on an upright metal column, or resting on a plinth. Double C-arm setups for fluoroscopy on two planes are installed for some interventional radiographic procedures, for instance in cardiovascular suites. All the different designs are specifically adapted to meet the needs of their specialized applications.

Mobile units are commonly referred to as surgical image intensifiers, which reflects the particular requirements placed on them, including high maneuverability, versatility of adjustment, operation on a power circuit fused at 16 A, quick positioning, compact dimensions, neat guides, smooth surfaces to satisfy hygiene demands in the operating room, and ease of operation as they may need to be worked by various users throughout the day.

All this costs money, of course, but prices of the equipment have remained more or less steady in spite of the repeated improvements they have undergone in the past and continue to enjoy. Mobile surgical image intensifier systems for control and documentation radiography and fluoroscopy, equipped with digital TV image storage, twin monitors and multiformat camera are now on the market at prices around DM 250,000. They are adaptable to a vast range of medical applications:

- ☐ Accident surgery
- ☐ X-ray examination of plaster casts
- ☐ Orthopedic surgery
- ☐ Hand surgery
- ☐ Operative cholangiography, cystography and pyelography
- ☐ Cardiac pacemaker implantation
- ☐ Cheminucleolysis
- ☐ Localization of foreign bodies
- ☐ Isotope therapy monitoring
- ☐ Controlled excision of biopsy specimens or placing of implants and introduction of sounds
- ☐ Endoscopy
- ☐ Intensive care

Among the advantages of fluoroscopic examination with an image intensifier and videoradioscopy camera (Fig1) is the substantial reduction of the radiation dose to which patients are exposed. In sum the benefits gained from using an x-ray image intensifier may be listed as:

- ☐ Low radiation dose
- ☐ Automatic control of dose level
- ☐ Better imaging quality
- ☐ Quicker working
- ☐ No need for absolute darkness
- ☐ No waiting by examiner for visual adaptation
- ☐ Individual and serial fluorographs made with reduced radiation dose by indirect film exposure

The dose is reduced by a further 60% or so when employing TV monitors in conjunction with digital image storage devices, as the image is recorded during exposure of the patient and can be

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* *Kurt Bartholmess. Friedrichshafen, West Germany*

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retrieved at any time subsequently for diagnostic interpretation. There are additional benefits deserving close notice:

- ☐ The examiner does not have to stay glued to a viewing lens.
- ☐ Several physicians can view the image at the same time.
- ☐ Image contrast is adjustable, meaning that reduced-dose fluoroscopy is possible at higher tube voltages.
- ☐ The fluoroscopic image can be transmitted to an external audience well away from the source of radiation.

Design of an x-ray image intensifier

The intensifier tube is an evacuated glass bulb containing a fluorescent screen with a directly coupled photocathode on its input (Fig 2). Exposure to x-rays causes photoelectrons to be emitted which are displayed on a smaller viewing screen by means of electrostatic lenses and an acceleration voltage of typically 25 kV, thus producing an image of amplified brightness.

Because of its substantial advantages, use of an image intensifier may be considered state of the art, especially as videoradioscopy, cineradiography and indirect radiography are all dependent on image intensification.

Image intensifier and videoradioscopy link

In videoradioscopy, which is a combination of radiography and closed-circuit television,the x-rays passing through the patient undergoing examination are inverted into visible light and picked up by a video camera.

The image is reproduced either by a conventional optical glass lens (Fig. 3) or through fibre glass optics. As with any optical system, losses due to reflection and scattering occur, resulting in reduced contrast of the image. Brightness and definition also deteriorate towards the image edges. Since the image must be scaled down for reproduction by the video camera, two lenses are necessary, meaning that a longer housing is needed. This longer housing entails a great risk of accidental collision with the mobile types of image intensifier.

With fibreoptics (Fig. 4) the image is picked up straight from the camera, thus avoiding scatter loss for the most part. Losses are, however, affected by the diameter of the fibre optic cables in relation to the wavelength of the light. This means that the image brightness is affected in this instance, too.

Standard closed-circuit TV systems employ a picture matrix of 512 X 512 or 640 X 512 pixels with a depth of 8 bits. Bandwidth varies among different makes and may be 8, 10, 15 or up to a maximum of 20 MHz. High-definition videoradioscopy systems on the other hand provide a matrix of 1024 X 1024 pixels by 10 bits with 1249 rater lines and a bandwidth of 25 MHz. This gives approximately twice the resolution and greatly enhanced contrast along with a better signal-to-noise ratio. Even with a very small radiation dose to the patient of 2.58 X 10^{-10} A/kg (10μR/s), the resolution attained with a high-definition x-ray TV system is significantly better than that with a conventional 625-line system (and a conventional dose of 5.16 X 10^{-10} A/kg = 20μR/s).

Digital image storage

Digital storage is essential for highest quality of visualization. When image storage capabilities were introduced to fluoroscopic examination a few years ago, using analogue technology at the time, they resulted in reduction of patients exposure but at the expense of poorer quality of reproduction. The situation only improved substantially with the availability of digital image processing, resulting in further reduction of radiation dose with a concurrent improvement in demonstration quality.

At present, digital multiframe memories are available to store 2 and 25 or 32 full video images. Two full images are stored in solid-state memories and 25 full images on magnetic hard disks.

The digital hard disk unit delivers stored images that are equal in quality to the original fluoroscopic image, thus permitting detailed evaluation of the visualized data subsequent to completion of the operation. It is also possible to make high-quality hard copies of the stored images on film for permanent documentation, which can be done at any time afterwards, outside the operating suite if necessary, and without any further generation of x-rays.

Dual-plane image storage

With two video monitors, observation on two planes can be simulated, simultaneously viewing

either one real-time and one stored image or two stored images.

Digital image storage provides the examiner with a number of special capabilities such as noise suppression in various stages and image subtraction. Noise suppression improves the signal-to-noise ratio and thus the image quality. Subtraction means that a stored image can be separated from the continuing scan.

Not only does digital storage of fluorographic images allow of reducing radiation dose, it simplifies recording of the images for documentation and their further processing. Documentation is performed with multi-imager cameras and its features are:

- ☐ Quick and reliable diagnostic interpretation of the image in the absence of radiation exposure.
- ☐ Subsequent documentation of the results of surgery on transparent film
- ☐ Avoidance of risk of breaking aseptic conditions such as exists with direct radiography
- ☐ Simplified, smooth procedure in the operating room with no interference caused by making radiographs
- ☐ No need for radiographic technicians to be present in the operating room
- ☐ Centralization of documentation on film for several operating rooms

Alphanumeric data input

Data can be entered in the stored images through an alphanumeric keyboard, for instance patient's name, hospital name, date of examination, and technical data of fluoroscopy/radiography. The keyboard is placed on the mobile cabinet supporting the two monitors and the multiimage storage and documentation devices. The data are displayed at the top and bottom of the monitor screen as entered and are also recorded on documentation films produced with a multiformat casette camera.

Technical description

A mobile surgical image intensifier system generally consists of two principal units, both wheeled for portability. One is the C-arm unit with the x-ray image intensifier mounted on one end of the arm and the x-ray tube of double focus vertical-anode type on the other end. The C-arm is fastened to a mechanical linkage arrangement which can be moved vertically by motor power to a height of 500 mm and is capable of swivelling horizontally through 12.5 degrees in either direction. The linkage is integrated into the voluminous and heavy section which contains the two high-tension generators for the image intensifier tube (up to 25 kV) and x-ray tube (up to 110 kV). Controls for the C-arm are similarly arranged on this section, the entire unit resting on a carriage whose swivel wheels have running and parking brakes. The C-arm stand is connected to the control and high-tension section by a flexible cable. The unit's center of gravity is located so as to ensure safe working with the C-arm in many positions. Weight of this unit varies between 198 and 230 kg for the various makes and equipment designs.

The second mobile unit is a cabinet on a wheeled carriage, supporting either one or two video monitors in a size of 51 or 44 cm diagonal, which gives a screen image measuring about 26 to 27 cm. In addition to the monitors, this cabinet can be fitted with digital image storage devices of various capacities. Types are available for storing one, two or multiple images (up to about 32). A multi-imager camera for documentation of x-ray images can similarly be mounted on the unit. This camera can work with optional (one, two or four) or preset image formats. Owing to the various options, weight of the second mobile unit may be between 50 and 164 kg. Installation of a multiformat camera on the monitor carriage makes for independent operation.

No film cassette holders need to be provided on the image intensifier tube of these mobile units in order to make radiographs. An image memory or storage device and a multiformat camera make juggling with film cassettes a thing of the past.

So as to obtain images rich in contrast with sharp contours and high local definition, especially for surgery on the hand and blood vessels, a matrix of 1024 X 1024 pixels at 8 bits depth and a highraster TV system of 1249 lines at 25 MHz bandwidth is desirable. Apart from larger digital storage capacity, this necessitates improved TV links and adaptation of the multiformat camera and storage device to the higher image intensifier and TV ratings. Only with such advanced technical design can fluorographic systems with image intensifier, video camera and digital processing facilities come close to the high definition of large-format film radiography.

The present summary of the subject was compiled with the help of data furnished by four manufacturers of the respective equipment. Further details of image intensifiers and associate units can be obtained via Medical Focus's Reader Service.

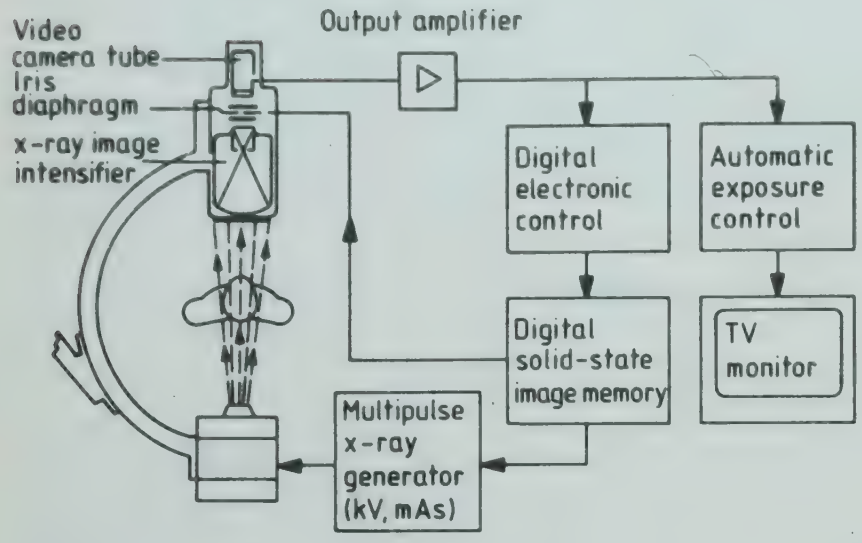

Fig. 1: Schematic of an image intensifier system with electronic control, image storage and television monitor

(Photo: Siemens)

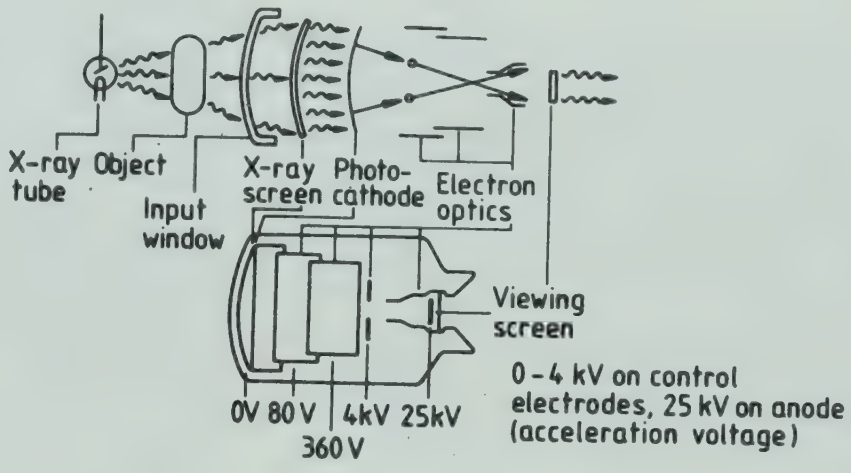

Fig. 2: Schematic of x-ray image intensifier

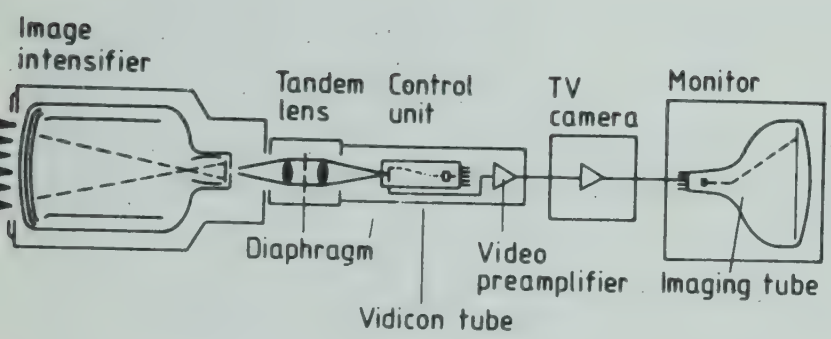

Fig. 3: X-ray TV link with glass lens optics

(Photo: Siemens)

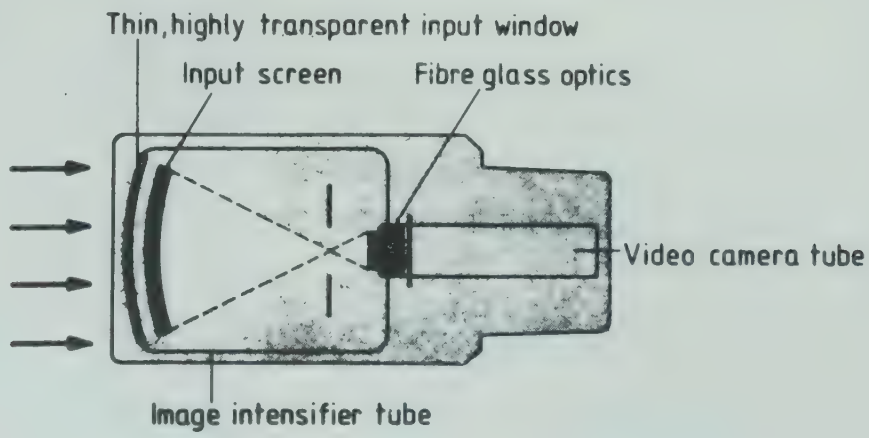

Fig. 4: X-ray TV link with fibre glass optics

(Photo: Philips)

Neurology

10. Present and Future Perspectives of Application and Utilization of Modern Technology in Neurology

Dr. S Jain and Dr. M.C. Maheshwari***

I Introduction

Since the end of the nineteenth century, a new image of hospitals evolved as institutions where patients of all social classes could expect to find the highest quality medical care and could reasonably expect to be cured of their disorders. In the twentieth century, the hospital has become the major institutional resource available to society for coping with problems of health and illness..

At this point it is important to distinguish between general and speciality hospitals, according to the type of service they offer. General medical and surgical hospitals provide diagnostic and treatment services for patients who have a great variety of health disorders. Most general hospitals are short term care facilities. Since many health problems require a level of medical treatment and personal care that extends beyond the range of service normally available to the patients in general hospitals, speciality hospitals typically restrict their services to patients with specific disorders. Speciality hospitals mostly have facilities for longterm care of the patients and the majority have specialities like cardiology, cardiothoracic surgery, neurology, neurosurgery, gastroenterology, endocrinology, nephrology etc.

Neurology is often regarded as one of the most difficult specialities of medicine. The aim of the neurologist is to arrive at a final diagnosis by artful analysis of the clinical data, aided by the least number of diagnostic procedures. Similarly, the strategy of diagnostic tests in a given patient should be based on the therapeutic and prognostic considerations, not on the physician's curiosity of some other factors. A few decades ago the only diagnostic procedures available to the neurologist were, examination of a sample of the cerebrospinal fluid, radiology of the skull and spinal column, pneumoencephalography, electroencephalography and radiopaque myelography. Now, through the advances in scientific technology the list of diagnostic tests available to the neurologist has been expanded to include a multitude of diagnostic methods. Some of these new methods are so impressive and non-invasive that there is a tremendous temptation to substitute them for a careful, detailed history and clinical examination. This tendency must be avoided. The treating neurologist should always keep in mind the importance of the clinical method.

The decision to carry out an investigation in any patient must be taken with great caution and the relevance and significance of any test result must be judged very carefully. Hence, the neurologist must be familiar with all the diagnostic procedures that he is likely to use, and their reliability. This needs to be emphasized once again when one is dealing with diagnostic texts involving modern technology because fo their non-invasiveness, increasing availability and ability to document lesions probably responsible for the neurologic abnormality - a fact which was a dream till a few decades ago.

II Imaging Techniques in Neurologic Diseases

Plain radiographic films of the skull and spine have been considered a 'routine' part of investigations in a neurologic patient. It has now been realized that plain films of this type rarely give any useful information if used as a 'routine' diagnostic method. 'Routine' X-ray films are not at all cost effective and carry a risk of radiation exposure. Improved techniques like pneumoencephalography (PEG), carotid and vertebral angiography and serial autotomography had increased the diagnostic yield in some special cases. However, the most important recent advance in neuroimaging has been the advent of

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computerized tomography(CT scanning). This technique has not only replaced many traditional imaging procedures like PEG but has revolutionized the ability to visualize nervous tissues (brain and spinal cord) in neurologic patients. It has also opened up a totally new field of bioneuropathology.

In CT scanning the attenuation coefficient of various structures in the brain and spinal cord is measured, with computer assistance, by more than thirty thousand two to four mm beams of X-rays, directed successively at several horizontal levels of the cranium and the spine. The differing densities of bone, CSF, blood, gray and white matter can easily be distinguished in the resulting picture. Brain tumors, hemorrhages, infarcts, abscesses, edema and degenerative changes can all be visualized with great accuracy and size and position of the ventricles can also be judged. The other advantage is that the radiation exposure is not significantly greater than that from plain skull films. In our country, where infections and infestations are still common, CT scanning has helped us to understand the pathophysiology and in the better management of conditions like CNS tuberculosis, abscesses and neurocysticercosis. With the newer generation machines, the brainstem, cerebellar and the spinal cord pathologies are also better visible. Even in the advanced countries CT scan was a novelty about a decade ago. In the last few years, it has become an integral part of diagnostic neurology, and even in our country, is now within reach of most of the patients who need it.

Another significant recent advancement over CT scanning has been the introduction of magnetic resonance imaging (MRI). MRI uses nonionizing energy in contrast to CT scanning and also provides slice images of the brain and spinal cord in any plane. MRI scan is carried out by placing the patient in a powerful magnetic field. The magnetic field causes the protons of the tissues and CSF to align themselves in the orientation of the magnetic field. A specific radio frequency (RF) pulse is then introduced into the magnetic field which causes these protons to resonate and to change their original alignment. The protons then emit the radio frequency energy which they had absorbed and this energy is subjected to computer analysis, which is converted into an image.

MRI has clear cut advantages over CT scanning. It gives a much better contrast between gray and white matter, is much more sensitive for many lesions in the central nervous tissue, has a greatly increased capacity to demonstrate brainstem and cerebellar pathologies (because of lack of bone artifact), and has no risk of ionizing radiations. Abnormalities of the hindbrain and syringomyelia are specially well defined by MRI. Despite the fact that MRI device is costly and requires special housing to contain its powerful magnetic field, it has become an important adjunct to existing CT techniques for neurologic diagnosis and has even replaced CT scanning in the diagnosis of many neurologic disorders. The basic technique of MRI has already been advanced to include 3-D pictures, spectroscopy and angiography. These advancements of MRI technology will have a definite impact on neurologic diagnosis in the next few years.

Various radioactive isotopes of mercury, technetium and arsenic have been in regular use for the visualization of tumors, inflammatory masses, subdural haematomas and some vascular lesions. These are expensive but simple and non-invasive procedures and now have a very limited role after the availability of CT scanning and MRI. Positron emission tomography (PET) involves introduction of a positron emitting substance into the body. The metabolic rate of a particular area of the brain is then reflected in the amount of positrons emitted and the energy of these positrons is then converted into a colour coded picture with the help of computers. PET is still a research tool and is being extensively used to study the altered physiology in various disease states.

The technique of angiography has been developed over the last 35 years and is a relatively safe method for the diagnosis of vascular abnormalities like aneurysms, vascular malformations, occlusion of arteries and veins, and, some mass lesions also. A recent refinement of angiographic technique has been digital subtraction angiography (DSA). It uses digital computer processing to produce an image of the major cervical and intracranial arteries. DSA can be carried out via venous or arterial route and the advantage over conventional angiography is that the amount of contrast medium required is much smaller. DSA is also considerably safer and more economical and reliably visualizes occlusions and stenosis of the carotid vessels, as well as large ulcerative plaques and aneurysms. Doppler flow study using ultrasound technology is the other noninvasive method to evaluate the carotid vessels and has been used as a diagnostic modality complimentary to DSA in such disorders.

Water soluble contrast media, such as metrizamide, are self absorbing and are being used with increasing frequency instead of oily contrast media like myodil (Pentopaque) for myelography. Radio-opaque myelography has been very useful in the diagnosis of spinal conditions like ruptured lumbar and cervical discs, spondylotic myelopathy and spinal cord tumours. The whole body CT scan also provides excellent images of the spinal canal and intervertebral foramen in three planes. The combination of metrizamide and CT scanning is a particularly useful means of visualizing spinal and posterior fossa lesions. Cranial and spinal bone scans are of immense value in visualizing tumours and inflammatory processes in cranial and spinal bones. The bone scan can be combined with gallium scan for the opacification of the soft tissues.

III Electrophysiological Evaluation in Neurologic Diseases

Electroencephalography (EEG) has been part of the clinical study of the patients with cerebral disease and also in the evaluation of the cerebral effects of many medical diseases. The ordinary EEG represents the record of electric activity of the brain under restricted circumstances. Over the years, EEG has been used in the evaluation of patients with epilepsy, brain tumour, abscess, subdural hematoma, cerebrovascular disease, head injury and various other diseases that cause coma and states of impaired consciousness. Despite its limitations of nonspecific abnormalities in most of the conditions, EEG is still useful in the evaluation and management of many patients with epilepsy. Different types of epilepsy can be recognised from the type of abnormal electrical discharges seen in the EEG and proper drug therapy instituted. Various activating procedures like hyperventilation, photic stimulation, natural and induced sleep record, whole night EEG record and EEG record with sphenoidal electrodes have been used to enhance the diagnostic yield. Although the advancements in imaging techniques have vastly restricted the utility of EEG in neurologic disorders, it is still a cheap, easily available and non-invasive technique which has its own place in the neurologic evaluation. Several technical developments have also occurred in electroencephalography. The availability of telemetric EEG, ambulatory cassette EEG recording, simultaneous video-EEG recording, magnetoencephalography and computerized brain mapping are some of the advances which have been shown to be important clinically, although in a restricted group of patients.

The stimulations of sense organs or peripheral nerves evokes a response in the appropriate cortical areas which could not be recorded till recently because of much larger back ground activity in the form of EEG. The use of averaging methods introduced by Dawson, in 1954, and the more recent development of digital computers have provided the means of overcoming these problems. A series of waveforms, modified at each relay station and recorded by distant electrodes can be maximized by the computer to a point where they can be easily measured in terms of their voltage and latency. These waveforms have been called as computerized evoked potentials. The three commonly used in clinical practice are the pattern shift visual evoked responses (PSVER), brainstem auditory evoked responses (BAER), and short latency somatosensory evoked potentials (SLSEP). The main indications of doing these tests are to obtain confirmation of a disorder of function in particular parts of the nervous system and to ascertain its nature or to quantitate the disorder in order to determine, by repeated examinations the natural course of the underlying illness. These tests have also been used to detect subclinical involvement of the nervous system in various neurologic disorders. PSVERs have extensively been used as a diagnostic tool in multiple sclerosis, and many other conditions affecting the optic nerves or visual pathways posterior to the optic chiasm. BAERs have been used with great advantage in disorders of the eighth cranial nerve and various conditions with abnormalities in the brainstem. SLSEPs have been most useful in establishing the existence of lesions in spinal roots, posterior columns and brainstem in such disorders as Guillian Barre syndrome, multiple sclerosis, and cervical spondylosis, even when the clinical data may be uncertain.

Electrodiagnosis of neuromuscular disease has been in clinical use for many years. Electromyography (EMG) and nerve conduction studies are the two techniques most commonly used. The abnormalities in amplitude, duration, and shape of motor unit potentials as recorded in EMG can help to differentiate a myopathic process from a neuropathic disorder. In addition, certain types of spontaneous activity and changes in the interference pattern can help in the evaluation of certain disorders like neuromyotonia, myotonic diseases, and other conditions with defective relaxation of muscle fibers. Single fiber electromyography (SFEMG) is a special technique for the recording of single muscle fiber action potentials, and is used to measure

fiber density and jitter. Fiber density is the index of the number and distribution of muscle fibers within a motor unit. Jitter is the variability of the interpotential interval of successive discharges of two single muscle fiber action potentials belonging to the same motor unit. SFEMG is particularly useful in the detection of disorders of neuromuscular transmission, especially myasthenia gravis. Fiber density and jitter are often markedly increased in neuropathic disorders causing denervation and reinnervation. They are usually normal, or only slightly increased in myopathic disorders.

The results of motor and sensory nerve conduction studies, expressed as amplitudes, conduction velocities, and distal latencies yield very useful information in many disorders affecting the peripheral nerves. Demyelinating neuropathies cause maximum reduction in the nerve conduction velocities. Focal compression of nerve, as in carpal tunnel syndrome, may produce localized slowing or blocks in conduction, perhaps because of segmental demyelination at the site of compression. Repetitive stimulation studies by the application of brief electrical pulses to the skin overlying a motor nerve have been used in the evaluation of patients with disorders of transmission at the neuromuscular junction like myasthenia gravis and the myasthenic syndrome of Lambert-Eaton.

Information about the conduction of impulses, through the proximal segments of a nerve, not obtainable by routine nerve conduction techniques, can be provided by study of the H reflex and the F wave. When conduction studies of the distal segments of peripheral nerves are normal, prolonged latencies of the H and F waves can be taken as evidence of disease in the most proximal segments of the nerves or spinal roots. Testing for conduction along the autonomic nerves, central motor conduction and central EMG have recently been standardized in various laboratories and are now being used in the evaluation of patients suffering from various diseases affecting the peripheral and central nervous system.

III Histopathological Evaluation in Neurologic Diseases

Muscles and nerve are two tissues commonly used for histopathologic diagnosis in various neurologic diseases affecting the neuromuscular system. Muscle biopsy specimen can be stained by hematoxylin and eosin and studied under the microscope. Special techniques are applied if it is desirable to visualize particular qualities of a disease. Various histochemical stains for enzyme content of muscle fibers are used in many laboratories in the diagnosis of some unusual myopathies. Electron-microscopy is useful in confirming abnormalities detected by histochemical staining and provides a refined means of studying other myopathies. Sural nerve is most commonly biopsied and can provide valuable data, even when examined by ordinary microscopy. Nerve fiber teased preparations and morphometric studies are also available in centres where nerve and muscle diseases are under investigation.

IV Immunological Tests in Neurologic Diseases

Recent advances in the filed of neuro immunology have made it clear that the speciality of neuroimmunology is not only concerned with the relationship between the immune and nervous systems but has great potential for helping to understand the pathophysiology and in the diagnosis, and also guide us in the planning and evaluation of therapy of many neurologic disorders. The introduction of laboratory methods like radioimmunoassay (RIA), fluorescent antibody techniques, detailed analysis of complement system and enzyme linked immuno-sorbent assay (ELISA) have boosted up many discoveries in this regard. Analysis and development of the HLA system gave further impetus to the research in the field of neuroimmunogenetics.

Elevated levels of CSF-immunologlobulins have been now documented in many conditions like multiple sclerosis, and subacute sclerosing panencephalitis (SSPE), etc. Various immunoglobulin abnormalities in the serum and or the CSF have also been documented in diseases of the peripheral nervous system like Gullian Barre syndrome (GBS), subacute necrotizing myelopathy, polymyositis, and myasthenia gravis (MG). The identification and detection of anti-acetylcholine receptor antibodies have contributed significantly to the understanding of myasthenia gravis; the identification of myelin basic protein has been another hallmark in the immunological aspect of many neurological diseases. ELISA is now being increasingly used for the development of diagnostic laboratory tests for many diseases of the nervous system which are common in India- tubercular meningitis and neurocysticercosis being the two most important. Immunological techniques are now being increasingly employed not only in the diagnosis of the type of

brain tumours but also to monitor the development and progress of these tumours with implications in prognosis and therapy. A new speciality of tumor-immunology has developed in the last few years. Immune mechanisms are now been investigated in a large number of other neurological disorders like motor neuron disease, neurological complications of AIDS, progressive multifocal leucoencephalopathy, ataxia telangiectasia and vasculitis associated with neurological diseases. With advancement in research, it is hoped that many specific 'immuno-modulators' responsible for the neuro-immunological diseases would be isolated so that more specific target-oriented immunological therapeutic measures can then be developed for use in clinical practice.

V Biochemical and Biologic Tests in Neurologic Diseases

A number of highly specific tests of serum, CSF and circulating red and white blood cells have now become available with the recent advances in biochemistry of metabolic neurological diseases. Largely this has resulted from the application by Dent of the paper chromatographic method for the analysis of aminoacids in the blood and urine. More recently, high pressure gas liquid chromatography, mass spectroscopy, and electron microscopy have continued to reveal previously unknown diseases and to clarify the basic biochemistry of old ones. Various laboratory tests including assay of an abnormal end product, enzyme content of various cells, and other sophisticated procedures have not only helped in the diagnosis of various diseases but have made mass screening and prevention of such diseases practicable. Now, it is possible to find patients, who, though asymptomatic, are at risk, and to introduce remedial measures to prevent injury to the nervous system. To assume this responsibility, neurologists require some knowledge of genetics, of biochemical screening methods, and of public health measures.

The revolution in molecular biology begun by Watson and Crick in defining the structure of DNA and by Nirenberg in deciphering the genetic code has clearly entered the arenas of neurobiology and clinical neurology. With the use of recombitant DNA technology, it is now possible to identify the mutations in genetic neurologic diseases and for antenatal diagnosis. The greatest progress in understanding genetic neurologic disorders has been with the autosomal and X-linked recessively inherited disorders, which are due principally to enzyme defects. Recombinant DNA approaches have been projected to have a great impact in the dominantly inherited diseases such as Huntington's disease, myotonic muscular dystrophy, neurofibromatosis, the spinocerebellar degenerations, and Joseph's disease. Radiolabelled cDNA probes for various viruses offer a new method to probe brain tissue from neurologic disorders of unknown cause. The technique of modern molecular biology has almost come to the bedside in the form of 'Gene therapy' in various medical conditions. Molecular biologists have found the brain tissue a fertile milieu. Neurologists will soon become familiar with and grow to rely on cDNA hybridization patterns in evaluating patients with genetic and metabolic disorders and, in the future, it is hoped, to be able to apply specific gene therapy to their patients.

In the end, it must be remembered, that any battery of diagnostic tests can be planned intelligently on the basis of good clinical information. With the availability of ever increasing list of diagnostic methodology, there is a likelihood of replacing the clinical evaluation by these laboratory tests. This reversal of the basic principle of clinical medicine shall be a great wastage of medical resources. In neurology, like other branches of medicine, the basic goal is the prevention of disease, because the brain changes induced by many neurologic disease are irreversible. When a disease process has already set in, it is the responsibility of every physician to reduce the morbidity and mortality. Many times the clinical method is inadequate so that these goals cannot be achieved by clinical examination alone. One then resorts to two other methods-diagnostic methods to identify and localize the disease process and institute remedial measures, and the use of genetic information and laboratory screening for the prevention of inherited disease.

Obstetrics and Gynaecology

11. Modern Technology in Gynaecology and Obstetrics Its Current State and Future Application

Dr. M. Karunakar and Dr. V.L. Bhargava***

I Introduction

Recent decades have seen dramatic advances in medical technology, many of them applicable to the field of obstetrics & gynaecology and to maternity care. New imaging techniques, fetal acid base and blood gas analysis, electronic fetal heart monitoring, amniotic fluid studies, sophisticated endocrine studies and invitro fertilisation, are just a few of the newer advances that have become commonplace components of the reproductive health care in most developed countries.

In selecting the appropriate technology, four criteria are to be considered, namely effectiveness, safety, technical feasibility and cost.

Technological interventions which can be applied at the community level, which do not require highly educated personnel, and which are amenable to easy maintenance and quality control should be given highest priority in developing countries.

Following considerations should be included in any proposal before introducing the new technologies in any country.

(1) Local evaluation of every new technology should be done before such technology is accepted and bought by a country.

(2) It is not enough that it is efficient for the diagnosis or treatment of a health condition, but it must be proved to be more efficient in lowering the morbidity and mortality rates already existing in that country. It should preferably be less expensive and simpler than the available technologies. When estimating the cost of any new equipment, it is not only the actual cost of the instrument and shipment, but also the cost of operation, maintenance, repair, including spare parts, and training of the staff which should be added.

(3) The Universities and health institutions which are the first to obtain and use a new technology, should participate in the local evaluation, and keep a continuous comparison of the new and old technologies so as to obtain objective evidence of the relative advantages and disadvantages of each one of them.

(4) The dependence of undergraduate and postgraduate trainees on high technology for their clinical work should be carefully avoided.

(5) Greater efforts should be made to apply the new knowledge acquired through sophisticated technologies for the development of simpler and less expensive ones.

(6) Any costly intervention which will reach only a minority of those in need, and because of its expense, will result in a curtailment of other more basic services, is not to be encouraged.

II Technology Applications in Obstetrics and Gynaecology

1. Hysteroscopy

Hysteroscopy is the oldest gynaecologic endoscopic procedure by which direct visualisation of endometrial cavity is done using an endoscope and a light source. It is done in patients with abnormal uterine bleeding, recurrent abortions, suspected uterine synaechia and congenital malformations of uterus, as a part of infertility work up, and in cases of adenocarcinoma uterus to see its extent. Some surgical procedures can also be performed through hysteroscope. These include, location and removal of intact or fragmented IUCD, resection of submucous myoma, removal of polyps, uterine septa and thick adhe-

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sions, LASER ablation of normal and abnormal endometrium as well as polyps. Silicone plug placement into the tubes for sterilisation, and salpingoscopy can also be done through hysteroscope.

As hysterosalpingogram can miss pathological lesions in 40% of the cases, it is always advisable to do hysteroscopy. Hysteroscopy has a significant role to play to evaluate endometrial response to exogenous hormone in primary/secondary amenorrhoea and is the instrument of choice to visualize the vagina of an infant or prepubertal child. In future hysteroscopy may replace most diagnostic D & C procedures.

2. *Contact Hysteroscopy* is very useful in describing colour, contour and vascular pattern of endometrium. The invention of microhysteroscope which does not require cervical dilatation enables the study of epithelial morphology of endometrium and endocervix. Very early dysplastic changes thus can be identified and biopsied for histopathological examination.

Colpomicrohysteroscopy is another advance in endoscopic techniques which evaluate the endometrium, endocervix and vaginal epithelium simultaneously with obvious benefits.

3. *Colposcopy*

Colposcopy is 20-40 times magnified stereoscopic visualisation of the epithelium and vascular changes of the vagina and cervix. Use of colposcopy and cytology for early detection of cervical neoplasia is one of the most challenging and rewarding area in gyneacologic oncology. Lesions of cervix when diagnosed and treated early are curable. Colposcopic examination with directed biopsy is indicated in (i) persistant minimal abnormality on Pap smear (ii) major abnormality on Pap smear and (iii) cervical lesions noted on routine examination.

Apart from diagnosing, colposcopy guides precise ablative treatment modalities in CIN thus reducing the morbidity due to other modes of therapy. Its role in follow up of these cases is well established.

Inflammatory, infectious, allergic and parasitic lesions, polyps, endometriosis and cervicovaginal malformations can be evaluated more precisely with colposcopy.

Ancillary devices like photography, cinematography, and television - all help in follow up, and teaching.

4. *Laparoscopy*

The impact of laparoscopy on the practice of gynaecology has been remarkable. Standard of patient care has improved and many puzzling questions have been answered without a proper laparotomy. Important indications for laparoscopy are:- (i) tubal ligation; (ii) investigation of infertile women with abnormal hysterosalpingogram, clinical suspicion of pelvic inflammatory disease, endometriosis and before tuboplasty or IVF; (iii) premature menopause and intersex; (iv) pelvic pain, pelvic inflammatory disease unruptured or old ectopic pregnancy or endometriosis; (v) second look laparoscopy for followup of endometriosis & tuboplasty; (iv) retrieval of missed IUCD.

Recent improvement in technology has led diagnostic laparoscopy to be transformed into surgical laparoscopy. Haemostasis can be obtained by endocoagulution, loop ligation, endoligation and endosutures with extracorporeal or intracorporeal knots. In some centres 40-45% of all gynaecological operations that require laparotomy are now performed by operative laparoscopy. Presently gynaecologic laparoscopic surgery is performed for: (i) omental adhesiolysis omental resection; (ii) excision coagulation of endometrial implants; (iii) fimbrioplasty, salpingostomy, ovarian biopsy; (iv) excision/puncture of ovarian cysts; (vi) enucleation of myoma; (vii) repair of uterine perforations; (viii) aspiration of oocytes; (ix) biopsy of peritoneal deposits; (x) salapingoscopy.

With the advent of automatic carbondioxide pneumo-peritoneum and with the attached facility of computer monitored simultaneous biochemical analysis of patient's blood - the procedure can be carried out safely. The preparation of the patient is similar to that of laparotomy.

5. *LASER Surgery*

Either carbondioxide, argon or neodimium YAG is used in several gynaecological conditions, either directly or under endoscopic guidance. Of all these, the ideal is ND-YAG. but in gynaecology CO2 laser is the one most commonly used. It is comparatively cheaper, more convenient & safer. CO2 LASER vaporisation or LASER excision is the treatment of choice for vulval carcinoma-in-situ providing bloodless field, rapid healing, and

negligible postoperative complications. LASER vaporisation of cervical CIN lesions is one of the important therapeutic modalities on out-patient basis. LASER excision of CONE for cervical intraepithelial neoplasia can be done under operating microscopic guidance. It results in superior success rate with minimal complications when compared to other modalities of treatment. Vaginal intra-epithelial neoplasia, vaginal condylomata, endometriosis, cysts, scars and other vulval lesions can be treated with laser with insignificant side effects.

The CO2 LASER system is superior for vaporisation of tissue and for surgical incisions, whereas ND YAG is superior as coagulator. Combined together they are useful for selective vaporisation of recurrent carcinoma cervix/vault, metastatic deposits in vagina, sacrum and groin. The advent of HpD LASER photoradiation therapy is one of the hallmarks of latest technologies in invasive gynaecologic oncology. This system helps in selective destruction of tumour tissue and avoiding dangerous ill effects on normal cells.

Introduction of LASER resectors has made it easier to carry out radical surgery in cases of vulval and vaginal malignancies. Extensive tumour with lymphnode involvement can be operated upon by minimal touch LASER beam incision. For disseminated ovarian carcinoma HpD LASER photoradiation therapy is the most ideal (theoretically speaking). Similarly all vascular tumours are best treated with LASER.

For genital warts, CO_2 LASER is currently the best method (90%) effective. It ensures complete removal, eliminates causative virus in surrounding epithelium and can be used in any site, with least scarring.

CO_2 laser though laparoscope is most suitable for adhesiolysis, evaporation and aspiration of endometriosis. Removal of small fibromyoma, hydatid cysts, uterosacral ligament transection to relieve pelvis pain can all be carried out. Myomectomy and metroplasty are better done by CO_2 LASER incision through laparotomy or hysteroscopy. Endometrial photovaporisation and photocoagulation both cause minimal morbidity with high success rate. Hormone assay Either radioreceptor or radioimmunoassay will enable the qualitative and quantitative estimation of hormones in blood circulation. The hormone profile forms a part of workup in several gynaecological conditions like primary or secondary amenorrhoea, galactorrhoea, infertility, premature ovarian failure, intersex, hormone-producing malignancies and ectopic pregnancies.

6. Steroid Hormone Receptor in Gynaecologic Cancers

Though there is difficulty in assaying steroid receptors, their content in normal and malignant tissue can now be estimated. This enables study of the relevance of tumour biology to the clinical management of some malignant conditions. Those endometrial cancers which have little or no cytoplasmic estrogenic and/or cytoplasmic progesterone receptors have been associated with poor prognosis. Apart from prognostic significance the progesterone receptor status seems to be exceptionally accurate in terms of selecting patients who will respond to endocrine therapy and those who will not. In case of cervical cancer this has a role in identifying aggressive tumours and keeping a vigilant followup in such cases.

New developments in receptor assays using highly specific antibodies and improvements in our understanding of the receptor mechanism and its relationship to other growth controls will surely add to the ultimate outcome.

In vitro cell culture:- The availability of invitro cell culture and drug sensitivity in the modern era makes it easier to choose appropriate antimalignant drug for a particular caner, avoiding unnecessary medication where drug resistance is a major limiting factor. On-going research and clinical trials in few cancer patients with the use of latest hybridoma monoclonal antibodies tagged with either antibiotics or chemotherapeutic agents and radiosotopes seems to be promising. This forms one important milestone for the rapidly expanding field of immunotherapy.

Antisense oligonucleotides: This technology which is yet to be studied in human oncology helps to block the proliferation of the malignant cells specifically by inhibiting the protein synthesis at ribosome level.

7. Urinary Investigations

Some of the advanced technologies in the diagnosis and management of urinary incontinence in vogue are: urodynamic studies like cystometry, uroflowmetry (twin or single channel) detrusor pressure monitors, video-cysto-urethrography, electromyography urethral electric conduction profile. All these are expensive & inva-

sive investigations, but have a significant role in selecting patients for surgical corrections. In neuropathic incontinence a new device (A.M.S. 800) i.e. artificial urinary sphincter is found to be very useful. As such it cannot be used widely due to its high cost (Rs. 52,000/-). Incontinence pants are also available, specially useful for geriatric patients.

8. IVF AND ET

In vitro fertilization and embryo transfer is a suitable method for treating tubal and idiopathic infertility. The success rates for oocyte pickup, fertilization and growth of embryos are close to 90%. Currently pregnancies occur in 20% of patients having oocyte pickup. Nevertheless three treatment cycles allow each patients a significant chance of childbirth. It is hoped that IVF & ET procedures will be improved and simplified so that other centres can easily copy the technique.

Freeze thawing of the embryos may improve the efficiency of the procedures as excess embryos obtained from a single laparoscopy may be used in subsequent cycles.

Freeze thawing of oocyte may also facilitate donor oocyte or embryo transfer. Both have medico-legal implications.

9. Microsurgery

Basically microsurgery involves optical magnifications, specialised surgical instruments, fine non-reactive sutures, minimal tissue trauma, precise anatomic dissection and careful placement of sutures. The essence of this technique is to minimise tissue damage, careful haemostasis, and constant irrigation to avoid dessication of the operative site. It is best suited for every form of tuboplasty including adhesiolysis, metroplasty and conservative surgical measures for ectopic pregnancy. There is a wide variety of operating microscopes, microsurgical instruments, electro-surgery units, suture needle combinations, and ancilliary equipment such as suction/ irrigating devices, oviduct stabilising clamps and intraluminal probes and stents. Recently, hand held lasers, tissue-adhesive dispensers, and tubal stapling devices for one step tubal anastamosis are available. Acsquisition of equipment should be based on need, functional design, durability and cost.

10. Chorion Villus Sampling

Enables obtainment of fetal cells as early as 7-9 weeks of gestation. These cells can be either studied directly under microscope or cultured upto metaphase and studied in detail. A number of chromosomal disorders, genetic disorders, and inborn errors of metabolism and haemoglobinopathies can be diagnosed in first trimester of pregnancy. Added to this the IMA technology (D.N.A. probe) is presently applied to study these abnormalities in greater detail. Technically, chorion villus biopsy is well established, and is 90% safe, so if any chromosomally abnormal pregnancy is diagnosed, termination can be done in first trimester, safely.

11. Amniocentesis

Its role & safety in the diagnosis and management of normal & abnormal pregnancies is well established. It is done at 16-18 weeks gestation. Fetal cells and enzymes in the liquor are studied for detection of genetic abnormalities. In III trimester L/S ratio indicating pulmonary maturity, and bilirubin indicting severity of Rh isoimmunisation can be estimated in liquor amnii. Research is being done to treat IUGR and oligohydramnios by administration of albumin containing solution.

12. Fetoscopy

Fetoscopy is a technique of direct visualization of fetus through endoscopy. It is used for prenatal diagnosis of a large number of congenital abnormalities and for fetal therapy in selected cases. Presently it is reserved for the identification of small discrete external structural abnormalities and for obtaining fetal blood sample, through cordocentesis and skin biopsy that express a specific genetic attribute not identifiable by biochemical or cytogenetic analysis of amniocytes or trophoblasts. Karyotyping from fetal lymphocytes takes only 3-4 days. Fetal anaemia due to severe Rh-iso immunisation is treated by transfusing matched blood; hypoalbuminemia of non-immune hydrops fetalis is corrected by direct infusion of albumin. In twin pregnancies in which only one fetus is congenitally malformed, selective foeticide by fetoscopic air embolism can be achieved. Direct access to the fetal circulation is an invaluable tool in the study of the physiology of the normal fetus and the pathophysiology of disease processes.

Fetal Therapy- In a few cases of obstructive hydrocephalous and uropathy, fetal therapy has been undertaken by placement of ventriculo and vesicoamniotic shunts respectively. Fetal medicine is advanced to the extent of infusing cell

precursors directly into fetal circulation for the correction of genetic disease.

13. Amnioscopy

Is visualisation of amniotic fluid vaginally through amnioscope. It is particularly useful for the diagnosis of placental insufficiency in high risk women. A minimum cervical dilation of 2 cm is necessary to pass the amnioscope. Amnioscope also helps in securing scalp electrodes on the fetal scalp and to obtain scalp blood for biochemical and gas analysis after the membranes are ruptured.

14. Ambulatory tocodynamometry

Domiciliary monitoring of uterine contractions is now possible with the availability of reliable, and simple ambulatory tocodynamometer. This technology contributes to the three critical areas of management in preterm labour (i) Screening of low risk women for the risk of preterm labour; (ii) early diagnosis of preterm labour in high risk women & thus (iii) early referral & treatment improving the outcome with tocolytic therapy. This needs patient eduction, availability of such costly equipment & communication system

15. Cardiotocography

Modern technology in management of labour in high risk mothers is cardiotocography. Fetal heart sounds are recorded by: (i) phonocardiography; (ii) ultrasound - in the form of doppler external/internal cardiotocography (iii) Electrocardiography - particularly in suspected cases of arrythmias of fetal heart.

All these methods are combined with tocographs, or tocodynamometers which record uterine pressure applied either externally or internally and the whole system is incorporated into twin channel recorder.

There are now new systems available which offer the facility of radiotelemetry of fetal heart rate and uterine pressure to a distant monitor (50-100 meters distant) which helps in assessment of fetal condition remotely.

For quantitative estimation of intrauterine pressure, different catheters are devised. Latest fibre-optic pressure transducer and another recent model-transducer tipped catheter are found to be very reliable but they are costly and cost effective analysis is yet to be evaluated.

The advent of high capacity microcomputers which can be used in delivery rooms analyse the data given by cardiotocography in relation to the clinical outcome and management.

Cardiotocography- based on Doppler principle has become the pivot upon which modern obstetric management of high risk pregnancies depends. Fetal heart monitoring by electronic cardiotocographs can be done either externally or internally; it may be continuous or intermittent. Different abnormal patterns seen are - early deceleration, late deceleration, variable deceleration, sinusoidal fetal heart pattern, tachycardia/bradycardia and other arrythmias. Foetal heart monitoring in pregnancy is done either by nonstress test or contraction, stress test; non reactive nonstress test, and positive stress test are indicative of foetal hypoxia. Continuous cardiotocographic recording of fetal heart sounds during labour will enable the diagnosis of early foetal asphyxia and timely intervention. Electronic fetal monitoring has been shown to be significantly beneficial in the prevention of neonatal convulsions in women at low risk of intrapartum fetal distress.

Apart from this, fetal scalp pH blood gas analysis, quantitative estimation of lactate, pyruvate, hypoxanthine, all add to the better assessment of fetal compromise and necessary intervention.

16. Ultrasound

Asonography is a noninvasive imaging technique utilising acoustic waves similar to sonar. The latest model is Grey-scale type. For obstetric examination linear scanner is better particularly in the second and third trimesters. Ultrasonic study has revolutionised the field of investigative obstetrics because of its apparently innocuous effect on the fetus. It has, with few exceptions, replaced radiography in obstetrics.

Notable accuracy is achievable in the assessment of gestational age of the fetus in the first half of the pregnancy, presence or absence of structural abnormalities, growth pattern and weight of the fetus, site, size and location of the placenta and, amount of liquor.

The risks involved in several invasive procedures like chorion villus biopsy, amniocentesis, fetoscopy, intra-uterine transfusion, intra-uterine surgical correction of some of the fetal ana-

molies have been reduced a lot when performed under ultrasonic guidance. Presently with the availability of B-mode realtime coupled with Doppler technique, the uterine and umbilical blood flow patterns which reflect fetoplacental function have been studied precisely. Introduction of M-mode has made structural and functional evaluation of cardiovascular system of the fetus possible.

Apart from the above mentioned uses, ultrasound is used for the evaluation of incompetent cervix, diagnosis & followup of hydatidiform mole, choriocarcinoma, threatened/missed abortion and pregnancy associated with pelvic tumour, CuT and fibroid.

In gynaecology sector, scanner is preferable, instead of the linear scanner which is suitable for obstetrics as it provides greater resolution of the pelvis. Presently the activity of resolution lies between 0.5 and 1.0 mm. With pulse value technique of U.S. the anatomic structures are identified by measuring the time for the sound wave to reach the structure and return. With Doppler U.S. technique the frequency of returning sound echoes is analysed to determine the velocity of the moving structures and measurement of blood flow. This helps in diagnosis of deep vein thrombosis of the leg.

U.S. is very useful in predicting the response of ovaries to ovulation induction drugs like human chorionic gonadotrophin injection, predicting timing of ovulation, and in prevention of hyper stimulation syndrome. It has a significant role in deciding the timing of artificial insemination.

U.S. has been invaluable in indicating the time and in guiding the needle for oocyte retrieval for In-Vitro Fertilisation and has replaced laparoscopy in most IVF Centres.

Ultrasound is approximately 90% accurate in recognising the presence of a pelvic mass. It can distinguish between solid and cystic areas within the pelvic mass but cannot give the tissue diagnosis.

U.S. has helped in the evaluation of retroperitoneal lymph nodes, presence or absence of metastatis in the other viscera, ascitis and renal involvement. Sonography is the method of choice to locate a missing intra-uterine contraceptive device. A few of the structural abnormalities of Mullarian system can be diagnosed by U/S alone. There are new transducers like transvaginal, transrectal and transvesical which are better for evaluation of ovaries and oocyte pick up. U.S. should be used as supplement to bimanual examination rather than a replacement for assessing pelvic masses. The simplest model with minimal ancillary attachments costs Rs. 3 to 4 lakhs. The main danger of ultrasonography is that it can be overused to the detriment of clinical skill acquisition, maintenance, and the economics of the health care system.

17. Computerized Tomography (C.T.)

C.T. is a major advance in diagnostic imaging that provides detailed two dimensional images. This technique is excellent in discovering pelvic mass, extension of pelvic malignant disease into retroperitoneal fat, and enlarged lumph nodes (more than 2.0 cm). CT guided biopsy (percutaneous needle biopsy) for tissue diagnosis will avoid laparotomy in many instances. CT scan is more useful to the clinician in terms of staging of malignant disease rather than diagnosis. In endometrial cancer CT scan is helpful in measuring the depth of myometrial invasion by the tumour tissue. One of the indications in gynaecology for CT scan is the assessment of a prolactin secreting microadenoma of pituitary gland. By using monoclonal antibody imaging, a normal sized lymphnode containing any tumor tissue can be identified.

CT is an excellent technique to confirm the diagnosis of ovarian vein thrombosis and missing IUCD (which is missed by U.S.). CT pelvimetry can also be done and is more accurate compared to X_ray pelvimetry.

18. Magnetic Resonance Imaging (MRI)

MRI has several distinct advantages over other forms of imaging. It does not use ionising radiation. MRI can differentiate normal tissue from malignant tissue and tissue with abnormal metabolism. This enables us to define the tumour margin; hence exact extent of the surgical removal of the tumour can be planned avoiding unnecessary extensive dissection. Endometrial invasion of choriocarcinoma can be exactly defined by MRI. MRI is most specific in the diagnosis of conditions that are associated with oedema. It is found to be very valuable in estimating the amount of blood flow through an organ and in turn the functional status of that organ.

This principle enables the assessment of functional activity of ovaries in relation to different stages of follicular development.

Role of MRI in obstetrics is rapidly expanding. Its indications are similar to that of U.S. Pelvimetry and evaluation of fetal organs - especially those which are poorly picked up by U.S., like lungs, are better assessed with MRI. MRI is found to be a better investigation for the study of placenta and internal organs of the fetus. MRI spectroscopy enables components of the body to be studied at molecular level. One of the most interesting applications of the MRI spectroscopy is the estimation of fetal cerebral energy metabolism, detection of fetal hypoxia and inborn errors of metabolism.

19. Cervical Vibrators

Electric motor-operated vibratory techniques with a frequency range from 73-102 Hertz is applied to the cervix and so far it is found to be simple and acceptable to the patient. It is particularly useful for ripening of cervix where presenting part is well applied to the cervix.

20. Automatic infusion system: is devised for precise control of exogenous Syntocinon administration to produce enough uterine contraction. This system includes intra uterine pressure monitor which in turn regulates rate of infusion of Syntocinon, to produce ideal types of uterine contractions.

With the advent of these techniques it is now possible to avoid the inexorable risk of caesarean section rates due to dystocia.

21. Labour Analgesia

Today, labour pains can be relieved by different techniques of analgesia - which are well standardised in many centres. Safe and effective relief of pain during labour and delivery is accomplished by skillful use of epidural analgesia. The development of continuous infusion epidural analgesia results in continuous pain relief, and thus in pain free joyous and memorable childbirth without lasting stigma of fear and pain.

Transcutaneous electrical nerve stimulation (TENS) marketed as obstetric pulsor - is one of the methods available today to alleviate labour pains. Its analgesic effect is not as good as epidural analgesia or narcotic analgesics but it has the advantage of having no side effects on the fetus and mother. Inconsistent reports exist that TENS reduces the duration of labour and incidence of operative deliveries. It is very simple to use. Imported models cost around Rs. 12,000/-. In our country the simpler models are available costing about Rs. 2000/-. Very recently it has been shown to produce rhythmic uterine contractions. Possibility of it being used for induction of labour exists. Its role in post operative incisional pain is well documented.

22. Modification in vaccum extraction models

- Soft cup (Takashi Kobayashi)
- O' Neil modification: A new method of traction for the vaccum cup which allows the direction of pull to be in the curve of the birth canal is particularly useful in those deliveries, where the vertex is in the midpelvis. Instead of metal cups, now, several others, made up of plastic with brush border, are available in order to minimise trauma to fetal scalp.

23. Newer Instruments for the Gynaecologist

A. Out Patient Surgery:

1. Very small biopsy forceps with DISPOSABLE SHARPJAWS (3,4,5, mm size) for vulval and cervical biopsies.

2. MASTERSON Endometrial biopsy kit (2,3,4,mm size) with a malleable aspirating curette attached to manually operated vaccum source.

3. Disias endocervical curette - operated with a vaccum hand pump- produces an excellent specimen and probably will become the standard endocervical curette.

4. Gynecyte endometrial sampler appears to detect 90% of existing endometrial cancer- from cost-effective point of view, this may became the method of choice (cytologic) for routine screening of low risk patients.

5. Silastic bands and clips and various qualities of electric current have been used to minimise injury to adjacent organs and the puncture site in tubal sterilisation.

6. Water's cautery unit incorporates a safer method of applying heat. This virtually eliminates the possibility of electric current transmission.

B. In Patient Surgery: The technological developments in important gynaecological surgery have occured primarily in the refinement of techniques, instruments and closure materials and devices. New synthetic absorbable material with prolonged tissue strength, Polydexanon (PDF), is available being three times stronger than any available suture material. Syncare stapler using absorbable staplers and clips - is a new addition to closure methods; steel staples are best suited for bowel anastomosis. Fibreglass stirrups with no pressure points are in use today to prevent patient injury,

Developments in endoscopic study, imaging, and miniaturised instrumentation will offer many opportunities for innovative diagnosis and treatment in gynaecological surgery. One among them, recently developed is ultrasound operated debulking device for ovarian malignancy (ULTRASONOTRIPSY).

In today's environment, instrument and technology selection requires that the surgeon appreciate the trend towards patient convenience and cost/benefit ratio of the procedure.

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Automated Obstetrics Dopple

Data on umbilical artery and uterine artery flow is now readily usable, with fast and reproducible analysis of doppler signals in a specialised software. This has made possible, automatic final data to be available to the obstetrician without cumbersome calculations or cursor manipulations.

The device is particularly useful for the obstetrician to take timely decision in compromised pregnancies associated with pregnancy-induced hypertension; compromised blood supply can be diagnosed eight weeks sooner than with conventional techniques. With increasing incidence of elderly primis, etc. especially in urban areas, timely action with the help of such devices could make all the difference.

Ref: medical focus, 6/1986 pp 22

12. Cervical Incompetence
Assessment by Ultrasound techniques

*A. El-Rass**

It has been estimated that cervical incompetence is the cause of up to one fifth of all late abortions. Methods other than ultrasound can be used for testing or demonstrating defects of the internal cervical os in nonpregnant women. This is done either by hysterogram or by passing a Hegar's dilator. However, none of these methods can be used during pregnancy.

Intensive ultrasound studies of the internal cervical os have been carried out by several investigators, with some authors documenting active intervention based on clinical and ultrasonic assessment [4-10].

Views differ greatly on when the internal os should be considered incompetent. Mahran [5] suggested that an internal os measuring 15 mm or more during the first trimeter, or 20mm or more during the second, be considered incompetent. Lumbroso [10] considered an internal os larger than 20mm as abnormal. Lewin reported that cervical incompetence can be diagnosed when the internal os is 24 mm or wider.

All these and other studies were performed on pregnant women. Reports regarding ultrasound study of the internal os in the nonpregnant state are lacking.

Measurement in the nonpregnant state

A study was undertaken at El-Fahd Polyclinic in Jeddah to measure the internal os during the nonpregnant state in women with a history of repeated late abortions.

Localization of the region of the internal os was made by longitudinal scan after Mahran's technique [5]. Using the full-bladder technique and avoiding overdistention, the angle between the bladder and the vault is used as a marker at the level of the internal os. The cervical region is scanned longitudinally at very close spacing, i.e., every few millimetres, until the widest anteroposterior diameter is obtained for measurement

Results

Diameter of the internal os was measured in 56 patients with a history of repeated abortions as the control group.

Mean diameter of the internal os in the group with repeated abortion was 10.63± 2.99 mm. Frequency of measurements obtained in this group is shown in fig.1 Mean diameter in the control group was 8.03 ± 1.16 mm, and the frequency for this group is presented in fig. 2.

As can be seen, the mean diameter of the internal os in the repeat aborters was larger by 2.03 mm than in the control group. This difference was found to be statistically highly significant ($p<0.001$).

Comparison of the diameter of the internal os in the two groups (Fig. 3) shows a normal distribution with a central tendency at 8 mm. The curve of the repeat aborters exhibits a distinct shift to the right, which denotes the difference between diameters.

Adding two standard deviations to the mean diameter of the control group (8.3 ± 1.16 mm) gives a figure of 10.3 mm, which is considered as the upper limit of normal in our study. Since the electronic caliper of the ultrasound machines used in the study does not measure fractions of millimetres, it seems reasonable to round this figure to 10mm and take that as the upper limit for an internal os to be regarded as competent. It follows that any internal os measuring more than 10mm in the nonpregnant state is considered incompetent.

Applying this rule, we found 39 percent of the patients with repeated abortions to have an internal os diameter exceeding 10mm. Hence they were assessed as having incompetent cervices.

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However, this does not mean that every internal os wider than 10mm leads to repeated late abortions, since 3 women (10 percent) in the control group with the cervical diameter of more than 10mm had no history of abortion. In at least 10 percent of the cases with repeated abortions, therefore, an internal os exceeding 10 mm was not the cause of abortion, whereas in the remaining 29 percent the incompetent internal os was the probable cause.

Comparison

Unfortunately, comparison between the internal os measurements obtained in the present study and those mentioned previously is not possible, since the bases are too different. In our reported study, measurements were made on nonpregnant patients, while in the previous studies the test subjects were pregnant.

In the earlier studies [11, 12] 4 mm and 8mm were suggested respectively as the upper limits of a normal diameter of the internal os in nonpregnant women.

Compared with these figures, we found that the upper limit of 100mm proposed in our study is substantially higher. This is actually due to two factors: the first is that our test subjects were multiparous women, which in itself results in increased diameter of the internal os; the second is that the previous measurement was made ultrasonically.

Based on the results of our study as reported and the data published, an internal os wider than 10mm when measured by ultrasound in the nonpregnant state is considered patulous. In this regard, ultrasound may be considered an important and valuable tool in the assessment of cervical incompetence.

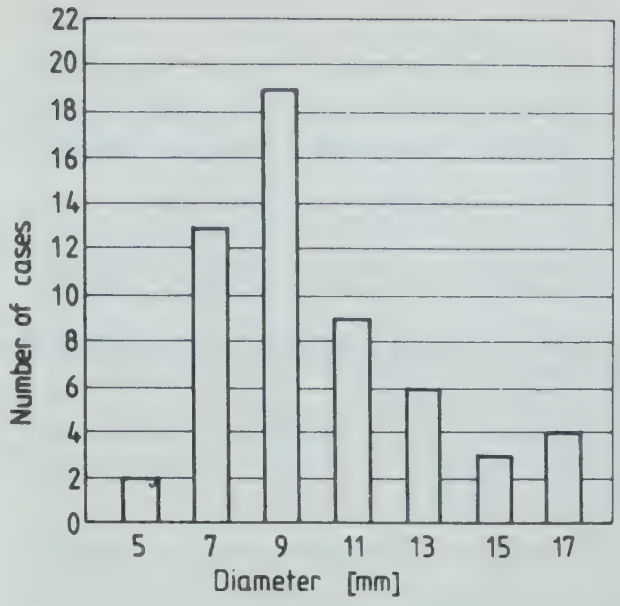

Fig. 1: Frequency of diameters of internal os in women with repeated late abortions.

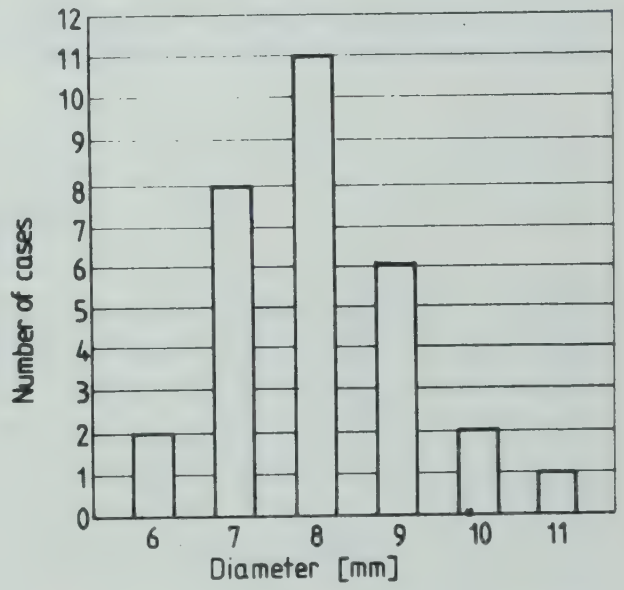

Fig. 2: Frequency of diameters of internal os in the control group

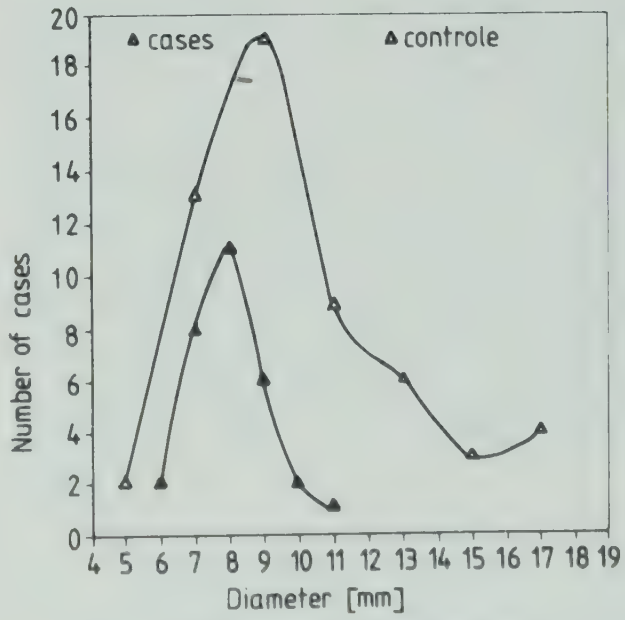

Fig. 3: Distribution of diameters in internal os in cases and control group of women with repeated late abortions

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Transvaginal Ultrasound Probe

Ultrasound diagnosis is increasingly popular as a safe, non-invasive procedure. To increase the scope of use of an ultrasound system, a transvaginal 5MHz phased array sector probe has been devised, which increases the applicability of existing ultrasound equipment without need for modification. With this new device, it is possible to detect very early gestation, monitor size and number of ovarian follicles, rule out ectopic pregnancies, general pelvic scan and screen for cancer. Aspiration/biopsy procedures can also be performed with an optional integrated biopsy catheter. The implications of the device for increasingly safe non-invasive gynaecological procedures, are obvious.

Ref: medical focus 1/1987, pp 44

Surgery

13.Present and Future Perspectives of Application and Utilisation of Modern Technology in Cardio-Thoracic and Vascular Surgery

*Dr. R.P Gupta**

I Introduction

A revolution is going on in medical technology. In the last three decades, there has been a tremendous advancement in medical technology in relation to cardio-thoracic and vascular surgery. As health administrators, it is not only essential to know the various technical advancements which are presently being used in this field, but also it is important to be aware of the present and future perspectives of application and utilization of this technology in view of the prohibitively high cost of these equipments. In the changing era of science some of these costly technology will soon get outdated in the near future, making these equipments of little use and these will be only lying as junk.

Progress in diagnostic technology is not a question of constantly overcoming technical difficulties, nor is it meant to serve the self satisfaction of doctors, but rather it must achieve greater benefit for the patient.

II Technology in Cardio-thoracic and Vascular Surgery

1. Tomography

This was used in the past as a very useful method to locate the position of any lesion in the lung in relation to chest wall. Since the advent of C.T. scan, its use has become rather limited.

2. C.A.T scan of Chest

C.A.T scan is a revolutionary tool, because it reveals soft tissue abnormalities such as tumors. This is a very important investigation for locating any lesion in the lung and its relation to various structures. It also indicates the presence of fluid or solid material in lung or pleural lesions. Some of the lesions which are rather small to be seen on the chest X-ray are better seen on the chest CT Scan and hence helps in making early diagnosis of chest lesions. By giving contrast injections and doing plain & enhanced scans, one can study the vascularity of a lesion.

3. Nuclear Magnetic Resonance - NMR

The newest tool science has produced for peering into the human body is the NMR Scanner, or nuclear magnetic resonance. It is considered to be even more revolutionary than the C.A.T. Scanner. It can see through bones, making its especially useful for the base of the brain and spinal column. NMR may eliminate the need for exploratory surgery in some patients. A major difference is that NMR, unlike CAT, does not use ionizing radiation. NMR draws information from the human body through a huge and powerful magnet, with 5000 to 20,000 times the earth's magnetic force.

The patient is placed into the doughnut shaped magnet, inside which is a circular coil. A certain level of radio frequency signal is put into the coil - an exact frequency that will attract a specific group of atoms in the patient's body. The NMR image makes use of body's hydrogen atoms. About one percent of the body's hydrogen atoms turn in the direction of the magnet. Then the radio frequency jostles them and they realign this time giving off energy in the form of a radio-wave, which is converted to an electrical signal, amplified, and then processed through a computer.

4. Endoscopy Procedures

Rigid endoscopes with fiber optic light carrier

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using Hopkins Rod Lens System, have been used for diagnostic procedures in esophageal and bronchial diseases. The commonly used scopes are of Storz Co (West Germany).

Presently the scopes that are used are flexible endoscopes. (Olympus, Pentax, Machida etc) With the help of these scopes, we can easily examine the tracheo-bronchial tree, esophagus, stomach, duodenum, etc., more completely. Washings can be collected and biopsy can be taken. Even transbronchial lung biopsy can be taken through the bronchoscope using special biopsy needles. For removal of foreign bodies and for diagnostic bronchoscopy in infants, one will still use rigid paediatric scopes.

Proper maintenance and use of these instruments is very necessary as the glass fibres can get easily broken, and repair and replacement is rather costly.

5. Pulmonary Function Tests

Sophisticated computerised machines are available for doing pulmonary function tests. One can do ventilation and diffusion studies to find out the hemodynamic abnormalities produced in various lung diseases, pulmonary embolism, etc.

6. Double Lumen Endo-Bronchial Tubes

These are useful for doing pulmonary function tests of each lung separately.

During lung surgery, where the secretions are present, the use of these tubes is a tremendous help as these prevent spilling over of secretions from one side to the other. The commonly used tubes are either Robert Shaw, Carlens or White's. There are separate tubes for right and left lungs. The following are the indications for one lung anaesthesia with double lumen endobronchial tubes.

a. Prevent contamination of non operated lung.
b. Allow unilateral positive pressure ventilation
c. Facilitate surgical exposure.
d. Unilateral lavage for alveolar proteinosis

7. Mechanical Ventilators

The objective of mechanical ventilation is to provide, though manipulation of airway pressures, alveolar minute ventilation which is adequate both in amount and distribution. These manipulations usually include both inspiratory and expiratory manoeuvres. In most circumstances, an increase in minute alveolar ventilation will result in more efficient gas exchange. The recent explosive increase in use of mechanical ventilators has resulted from a combination of circumstances.

a. More extensive major operative procedures and more poor risk surgical patients who require post-operative ventilatory support.
b. Early recognition of impending respiratory failure.
c. The concept that post-operative and post-traumatic respiratory failure can be minimized or prevented by aggressive early institution of airway pressure therapy.

Improved technology and increased understanding of pathophysiologic mechanism that underlie ventilating and respiratory failure have made therapeutic advances possible in the treatment of patients needing intensive respiratory care.

Classification of Mechanical Ventilators

Function	Ventilator
(i) Time Cycled	Air Schields
(ii) Pressure Cycled	
a) Flow adjustable	Bird Mark 7, 8
b) Flow sensitive, Time cycled control	Bennett PR-2
(iii) Volume cycled	Engstrom 300 Emerson' Bennett MA-1 Bourns Bear 2 Ohio Critical care Siemens Servo ventilator

Most commonly used ventilators are volume cycled ventilators as these deliver a preset volume in the lungs even in cases with high airway resistance.

8. Esophageal Manometry

The measurement of intraluminal pressures within the esophagus has become an important and reliable diagnostic technique in the evaluation of esophageal disease, particularly those characterized by anomalies of esophageal motility. Manometric studies are performed using sa-

line filled polyethylene or PVC tubes with open end lateral orifices. Usually the assembly consists of three to four tubes with orifices spaced 5 cms apart and connected to strain guage manometers. The pressure changes are recorded graphically by an appropriate recorder. Tests which are done are -

(a) PH reflux test
(b) Acid Cleansing test
(c) Acid Perfusion test
(d) Potential difference determination.

9. Esophageal Scanning Studies

Technetium-99m scanning has been used to identify mucosal change in patients with Barrett's Esophagus and to diagnose tumors of esophagus. It has been suggested that (Tc 99) scanning is a safe and sensitive noninvasive method of detecting and quantifying gastro-esophageal reflux.

10. Dilatation of Esophageal Structures

The various dilatation techniques which are used are-
(a) Hurst mercury bougies
(b) Maloney bougies
(c) Eder Puestow Olive tipped flexible bougies
(d) Balloon dilatation of esophageal stricture using Bard Baloon dilators.

This is the best and the latest technique for dilating the strictures under vision. The balloon catheter goes through the biopsy channel of the G.I.F. Q gastroscope and the balloon is placed in position through the narrowed orifice of the stricture and inflated with water upto 30 cc gradually, thus dilating the stricture upto 15 - 18 mms.

11. Diaphragmatic Pacing

The first use of electricity to stimulate respiration in humans is credited to Christopher Hufeland, who in 1783 proposed this technique for treatment of asphyxia neonatorum. Beginning in late 1950, Glenn and associates have actively pursued the development of clinical application of chronic diaphragm pacing using radio frequency signals to stimulate phrenic nerves through intact skin.

The only commercially available diaphragm pacer is made by Avery Laboratory, located in Farmingdale NewYork and consists of four components. Two of these components, the transmitter and the antenna are extra-corporeal, the other two, the receiver and the electrode assembly are implanted.

Diaphragm pacing can support a patient's respiratory needs only if there is a normal diaphragm to contract, expanding lung parenchyma that is capable of satisfactory ventilation, and alveolar capillary gas exchange. Pacing is therefore contra-indicated in cases of diaphragmatic paralysis resulting from-

(a) Destruction of the anterior horn cells at the level of 3rd, 4th and 5th cervical vertebrae,
(b) Damage to the peripheral neurons of the phrenic nerve.
(c) Impaired diaphragmatic function secondary to atrophy, eventration, myositis and muscular dystrophy; or
(d) Severe damage to the pulmonary parenchyma such that voluntary hyperventilation does not result in an improvement in arterial pO2 or pCO2.

Specific Indications

(a) Central Alveolar hypoventilation.
(b) Chronic Obstructive Pulmonary disease.
(c) Pathologic lesions of the Brain stem.

12. Angelchic Prosthesis for Repair of Hiatus Hernia

This is a silicone gel-filled circular device with tapes at the ends to put around the cardio esophageal junction to prevent reflux in cases of hiatus hernia. Though it is a costly device, it has found tremendous use in recurrent hiatus hernia cases.

13. Pleuro Jugular Shunts

In cases of malignant pleural effusion and cases of fibroma or mesothelioma of pleura, where surgery is not possible due to other causes, silicone shunts are used so that the fluid from the pleural cavity goes into the jugular vein and in the systemic circulation, thus avoiding dyspnoea and massive collection of fluid in pleural cavity. These shunts have a one-way valve incorporated and lie in the subcutaneous tunnel.

14. Endoscopic Ultrasonography

The introduction of Endoluminal Ultra-

sonography via fiberoptic endoscope, created a new diagnostic aspect for the examination of hollow organs. Unlike ultrasonography, endosonography provides a cross-sectional view of the various wall layers and the adjacent structures. Endosonography is not impeded by "ultrasound barriers", such as air or bone structures. Furthermore owing to the small distance to the target organ, high ultrasound frequencies may be used, resulting in high resolution of the "endosonographic" image.

Endosonography is performed with an echoendoscope, which possesses side viewing optics and an echoprobe at its tip. The echoprobe is typically surrounded by a balloon, which may be filled with water in order to exclude air from around the probe and to position the endoscope in the center of the lumen. The cross-sectional examination of the esophageal wall permits the differentiation of five layers.

In summary, endosonography may become a valuable tool in the early preoperative staging of esophageal carcinoma, providing precise information on the extent of the tumor and the degree of para esophageal invasion, and permitting differentiation from other mediastinal masses.

15. Angioscopy

The advent of an ultra-thin fiberoptic instrument and new optical techniques for more accurate diagnostic and therapeutic approach to the blood vessel are now possible. At present, flexible optical scopes with multiple channels and outer diameters of 1.5 and 2.8 mms are available for viewing or performing procedures under direct vision.

Angioscopy provides-

(a) distinct visualization of various occlusive diseases such as thrombus (fresh or organised), atheroma or ulcerated plaque.

(b) assessment for operative decision making and improved quality of surgery

(c) detection of unsuspected intimal flap or clot after completion of a procedure that prevents thrombus formation in bypass surgery.

(d) Possibilities of intraluminal manipulation such as valvulotomy and laser recanalization etc.

16. Balloon Angioplasty

Percutaneous balloon angioplasty is an established technique for treating selected patients with arterial disease. The ideal case is an isolated stenosis. Success rate in such cases is about 75% in femoro-popliteal occlusion. This technique is now being used for coronary artery blocks and is called coronary angioplasty (PTCA - Percutaneous transluminal coronary angioplasty).

17. LASER Angioplasty

A laser catheter is used adjunctively with balloon angioplasty in totally blocked atherosclerotic lesions of peripheral arteries and coronary arteries. The device bores through difficult lesions with a heated metal sapphire tip and avoids the risk of direct beam delivery which causes perforation of the vessel. In future, this will be used frequently for coronary angioplasty when better tips and catheters are available for delivery of laser energy only to the plaque.

Lasers have been used in arterial surgery experimentally and in clinical practice principally in techniques with microvascular anastomosis and recanalisation of athero-sclerotic vessels. In microvascular anastomosis, spot welds can be made joining small vessels of 1mm or less in diameter or by coagulating collagen or blood around the weld to act as a support.

With blocked arteries in arteriosclerosis it has been shown that athero-sclerotic plaque can be vaporised with various lasers, a technique that is especially effective when the plaque is mainly composed of cholesterol. Calcified plaque is more difficult to remove. The technique differs from endarterectomy, where plaque and occluding thrombus are removed surgically.

Several clinical studies have been made using neodymium yttrium aluminium garnet (YAG) or argon lasers to racanalise occluded femoral arteries. The failure rate seems higher than that of surgical methods, either because of failure to vaporise calcified plaque or because of immediate thrombosis. Perforation of the artery is the main complication. The effect of vaporised plaque debris on the peripheral vascular bed seems to be minimal but may depend on the quantity of the plaque treated.

So far the results do not compare favorably with established methods of treatment by surgery or, indeed, by balloon angioplasty. There may however, be a place for a combination of percutaneous laser treatment with balloon angioplasty, with the obvious advantage that patients do not need to have surgery.

18. Doppler Mapping of Blood Vessels.

With the advent of colour doppler the flow through the various vessels can be depicted along with the blocks, if any present in them. This is very useful in clearly delineating the anatomy and flow in carotid arteries and the peripheral vessels, thus avoiding the need for angiography. The combination of B-mode and pulsed doppler ultrasound is also suited to map and quantify occlusive lesions from the aorta down to the proximal calf arteries with an accuracy similar to arteriography. These are now applied to intestinal and renal arteries also.

19. The Vascular Laboratory - Advances in noninvasive techniques

Recent advances in technology have further increased the diagnostic potential of the noninvasive vascular laboratory. They include measurement of transcutaneous oxygen pressure, laser Doppler flowmetry and intravital microscopy with and without the use of flourescent dyes for analyzing hemodynamics of the skin and microvascular morphology, capillary flow velocity and transcapillary exchange of solutes.

20. Heparinised Shunts for Thoracic Vascular Operations

The introduction of polymers with wall-bonded heparin allowed for the introduction of a temporary tube shunt system, that can be employed in a safe manner. The first by-pass shunt with a wall-bonded heparin was a polyvinyl tubing with a graphite surface that was subsequently immersed in benzalkonium chloride and then in heparin. Subsequently an improved heparinised surface was developed by polymer chemists at the Battelle Columbus Laboratories and this coating is called the TDMAC - heparin surface. This obviates the use of systemic heparinization during surgery.

Indications

(i) Aneurysm or trauma involving descending thoracic aorta

(ii) Patients requiring an operative procedure on the innominate artery.

(iii) Atypical coarctation of aorta proximal to or involving the left subclavian artery.

(iv) Resection of aneurysm of the upper aspect of abdominal aorta.

(v) Carotid endarterectomy.

21.Auto Transfusion

In cases of aneurysm of aorta, the blood during surgery is collected by the suction tube, filtered and after proper anticoagulation is retransfused to the patient during surgery, thus decreasing the need for blood from blood banks. This is a very safe procedure and lot of such containers ready for use are available in the market.

22. Embolectomy Catheters

Fogarty Embolectomy Catheters are used to remove clots from peripheral vessels. These are of great use for saving an ischaemic limb with recent embolic episode.

23. Vascular Grafts for Bypass of Small Caliber Arteries

The standard for coronary bypass is now clearly the autogenous internal mammary artery (IMA). Complete revascularization of the left ventricle can be attained in most cases using IMA and Saphenous vein as sequential anastomosis.

Properly preclotted, non-crimped, externally supported Dacron grafts with an external velour surface merit consideration as the standard for axillofemoral bypass. The limitation of this graft is its dependence on a precise technique of preclotting to transform the Dacron frame work into a bio-synthetic complex of dethrombinated fibrin and Dacron.

The autogenous saphenous vein is clearly the standard for below-knee bypass. However, for above knee femoropopliteal bypass, the results obtained with Polytetra flouroethylene, (GoreTex), umbilical vein, and externally supported non-crimped Dacron prosthesis are sufficiently competitive with the results obtained with saphenous vein to make their use as an acceptable option in the above knee location. The saphenous vein is, thus saved for use in the more demanding below knee location such as femoropopliteal, femorotibial, or femoroperoneal bypass.

Whether Dacron, Teflon or PTFE, none of the the prostheses developed has been totally free of deterioration.

24. Cardiac Catheterization and various procedures done in Cardiac Cath Laboratory

a. Right Heart Catheterization

Under sterile conditions, a plastic radiopaque catheter is inserted in the right atrium though a peripheral vein (brachial or saphenous). Catheters are available in different sizes and models

depending on the procedure or the caliber of the vessel. Pressures are best recorded with open end catheters, while for angiography closed-end catheters are used to prevent recoil and intramural injection of contrast material. This helps to find out pressures in various chambers and to calculate cardiac output, systemic flow, pulmonary flow and pulmonary vascular resistance.

b. Left Heart Catheterization

In this the catheter is placed from a peripheral artery and is carried across the aortic valve into the left ventricle, thus recording pressures and doing angio-cardiography. Special catheters are being used nowadays for coronary angiography, coronary balloon angioplasty, etc.

The various procedures which can be done during cardiac catheterization are as follows -

- Recording of pressures.
- Calculation of flows.
- Calculation of valve areas.
- Indicator dilution techniques.
- Intracardiac Phonocardiography
- Intracardiac Electrocardiography
- Bundle of His Electrocardiography
- Calculation of myocardial wall tension and myocardial oxygen consumption
- Angio Cardiography
- Selective Angiocardiography and coronary angiography.

c. Cryosurgical Ablation of the A.V. node His Bundle-A new method for producing A.V. Block

C.C.S - 100 cardiac cryosurgical system allows the surgeon to control temperatures to -60° c. This is used for controlling A-V node reentry, WPW syndrome, venticular tachycardia and ventricular fibrillation. A potential application of the cryosurgical technique might be ablation of sites of dysrrhythmias (i.e. ectopic foci, re-entry circuits, accessory pathways).

25. Non-Invasive Technique to Diagnose Cardiac Diseases

(a) Echocardiography

Safest and a very reliable method to find out presence of pericardial effusion and thickening, enlargement of cardiac chambers, presence of clots in the heart, for finding out the size of various valves, and calcification of valves. This is a very important non-invasive method which tells about the myocardial thickness and areas of hypokinesia, akinesia and venticular aneurysm.

(b) Tread Mill Test

Continuous electro-cardiogram is taken while patient moves on a treadmill which has computerized measurement of exercise given,heart rate, blood pressure and ECG. By this test one can find out the occult coronary artery disease.

(c) Holter Monitoring

A recorder is put on the patient and ECG leads are connected. The patient performs all his activities and for 24 hours, the ECG is continuously being recorded. A computer does the analysis of all the beats and indicates regarding ectopics, bradycardia, tachycardia etc. This test is very useful in diagnosing patients with sick sinus syndrome, brady-tachy-arrhythmias etc.

(d) Thallium Scan

This shows the myocardial uptake of the radio nucleotide during various phases of the cardiac cycle. The pictures of heart are taken during systole and diastole, during rest and exercise and thus one can calculate the ejection fraction and clearly delineate the areas of poorly or non-functioning myocardium as opposed to normally contracting heart muscle.

26. Cardio Pulmonary Bypass

This is a technique by which the pumping action of the heart and gas exchange functions of the lung are temporarily replaced by a mechanical device, the pump oxygenator attached to the vascular system of the patient. Cardiopulmonary bypass using hypothermia has become an indispensable technique for most kinds of cardiac surgery today. The apparatus available for cardio pulmonary bypass changes continuously but some general points are important-

- Venous reservoir
- Oxygenator- Bubble or Membrane type.
- Efficient heat exchange
- Arterial pump
- Arterial line pressure.
- Arterial bubble trap
- Low Porosity arterial filter
- Cardiotomy Suction Lines.

The pump oxygenator is designed to minimize priming volume.

27. Intra Aortic Balloon Pump(IABP)

IABP counterpulsation, by putting a balloon catheter in descending aorta and synchronizing its deflation and inflation during systole and diastole has been used in the treatment of cardiogenic shock as a temporary cardiac supportive measure. Recent developments in the technique of introduction of the Intra Aortic Balloon Catheter have led to significantly fewer complications and an increased success rate for insertion.

Continued research and development of improved mechanical circulatory assistance devices is required to achieve an ideal device. Some of the criteria for an ideal mechanical circulatory support device are as follows-

(i) Hemodynamic effectiveness
a) Reduction of myocardial oxygen consumption by decreasing preload and after load
b) Augmentation of cardiac output.
c) Augmentation of coronary blood flow
(ii) Minimal invasiveness and comfort for patient.
(iii) Safety
(iv) Ease of application and operation.
(v) Transportability
(vi) Effectiveness and safety for prolonged use
(vii) Lack of requirement for continuous heparinization.
(viii) Reasonable cost.

Unquestionably, continued improvement and progress can be expected in the future. Prolonged circulatory support and perhaps, eventually, total artificial heart function may well be the major objectives of future progress in the field of circulatory assistance.

28. Artificial Prosthetic Valves

Various types of valves are available in the market for replacement of diseased calcified incompetent cardiac valves. These are of 3 types -

a. Homologous Valves - made from pericardium or fascialata and supported on a stent

b. Heterologous Valves - Valves derived from sheep or calves, sterilized and supported on stent

c. Prosthetic Valves - Valves made of silastic, carbon, graphite, and ring stents made of titanium. These are of two types (a) central flow (b) peripheral flow

The valves can be either made in Ball and Cage type or tilting disc type. Ideal valve is not yet available. The various valves which are available in the market are Star Edwards, Bjork Shiley, Carpentier Edwards, Hancock Porcein Prosthesis. The most important complication of these valves are (a) Thrombogenicity and embolic complications, (b) Infection, leading to bacterial endocarditis, (c) wear and tear and fatigue of material, giving rise to valvular incompetence and periprosthetic leaks, etc.

29. Artificial Heart

Development of a total artificial heart or left ventricular assist device would have obvious clinical usefulness, as a definitive treatment for end-stage heart disease when all other modalities fail. In addition to problems of pump design and energy supply, the artificial heart offers a large thrombogenic surface to the blood. With advances in design and development of less thrombogenic materials, the goal of a total artificial heart or a left ventricular assist device is closer to being reached. Recently such left ventricular assist devices have been used in patients for 3-4 days to support them.

A challenge for the future is to design a total artificial heart with flow characteristics and blood compatibility that will permit long term application in man.

30. Cardiac Pace Makers

This is a device which is used to give an impulse to the heart when it misses a beat. There are two types of pace-makers (a) External or Temporary (b) Permanent.

In external pacing the lead is placed percutaneous tranvenously in the right ventricular apex and connected to externally placed pulse generator. In permanent pacing, the pulse generator, which is about 40-50 gms is put in a subcutaneous pocket in the pectoral region and connected to the lead.

Pacemakers can work at fixed rate or demand mode. Most of those used nowadays are demand pacemakers, stimulating the right ventricle. In these cases, the stimulus is given to the ventricle, irrespective of the atrial contraction. Nowadays the trend is to do physiologic pacing by using dual chambered pacemakers (one lead in right atrium and the other lead in the right ventricle), thus giving rise to physiologically syn-

chronized contraction and producing better cardiac output and performance.

Pacing can be done either on the endocardial surface (transvenous route) or from the epicardial surface (by putting electrodes on the epicardium) during operative procedures.

Conditions that may require pacing are

(a) Sick sinus syndrome
(b) Tachycardias
(c) Atrial fibrillation with slow ventricular response
(d) Fixed complete heart block.
(e) Intermittent complete heart block
(f) Intra-ventricular conduction defects

The commonly used pacemakers are from Medronic, Telectronics, Pacesetter, CPI and Biomedics. The newer ones can be programmed from outside by putting a magnet over them and one can change the rate, amplitude, and various other parameters.

Wound Healing - Hyperbaric Oxygen Chamber

Delayed wound healing is a frequent complication met within surgical practice, being associated with skin ulcerations in diabetes, venous stasis, post surgical infection, gangrenous lesions, pressure sores, amputation stumps, skin grafts, burns and decubitus ulcers, the principle of applying pressured oxygen topically to the wound site, through portable hyperbaric oxygen chambers, has been successfully employed to accelerate wound healing. Two chamber types have been devised - one designed for treating lesions of the extremites, and another for sacral/lumbar lesions. Each chamber is completely portable and operates entirely on the hospital oxygen supply.

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14. Laser Surgery–
Application of CO2 lasers in the treatment of breast cancer

*K. Dinstl**

Studies—experimental and clinical—and results using CO2 and Nd:YAG lasers in about 1,500 operations since 1975 are reviewed in this article. Advantages of laser surgery have been observed in surgery of the breast, in anal surgery, sacral sinus, in chronic inflammations, and in operations on tumors of the skin and connective tissue. The survey shows where laser application is indicated and observes where it is still a matter of controversy.

Laser is the acronym for light amplification by stimulated emission of radiation. The laser beam is produced by an optical amplifier stimulated by additional energy supply. Depending on the type of amplifier, beams of different wavelength possessing a broad spectrum of qualities are produced. These laser light beams can be reflected by mirrors, deflected and focused by lens systems like any other light. According to the composition of the optical amplifier, three main types of laser are distinguished: solid-state lasers, gas lasers and liquid lasers. In medicine, the most common systems are the helium neon laser, argon laser, carbondioxide laser, neodymium-YAG laser and the ruby laser. The ruby laser is used in ophthalmology whereas in surgery the YAG lasers predominate. The most recent development is excimer lasers used in vascular surgery and angiology.

Our experience is based on work with the CO2 and YAG lasers in general surgery. Due to its qualities (wavelength 10.6 µm) the CO2 laser is used for noncontact cutting of tissue. Cutting is performed by the absorption of the laser beam by the tissue and its conversion to heat, producing very high temperatures of some hundred degrees celsius and thus vaporizing the tissue. Considerable development of fumes has to be managed by suction take-off.

The advantage of CO2 lasers are:

- ☐ cutting without mechanical force.
- ☐ minimizing of parenchymal bleeding by sealing of small vessels.
- ☐ minimal postoperative wound infection,
- ☐ very little postoperative pain,
- ☐ no interference with electric monitoring systems,
- ☐ sealing of lymph vessels—an advantage that could be important in tumor surgery but is currently a subject of controversy.

Experiences

At the First department of Surgery of Krankenanstalt Rudolfstiftung and theLludwig Boltzmann Institute for Laser Surgery in Vienna, a CO2 laser has been in use since 1975, during which time 1,500 operations have been performed.

Advantages have been observed in breast surgery, anal surgery, sacral sinus, chronic inflammation, fistulas, vascular ulcers, amputations in infected tissue and operations on tumors of the skin and connective tissue. In abdominal surgery the use is very limited; above all expectations concerning surgery of parenchymatous organs were not met.

By adapting a microscope, the CO2 laser is used in otolaryngology for operations on the larynx and vocal cords (135 cases at our hospital). Gynecologists at our hospital used CO2 laser in 42 cases of carcinoma of the vulva and kraurosis vulvae.

Breast surgery

Most operations were done for diseases of the breast. The use of CO2 lasers in breast surgery is based on the following characteristics:

- ☐ reduced bleeding,
- ☐ reduced postoperative pain,
- ☐ reduced postoperative wound infections,

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- ☐ possibly reduced local recurrence (but no significant results compared to the general survival time).

Reports on the results of laser surgery in cancer patients have been controversial. The main argument for the CO2 laser in tumor surgery is based on the theory of sealing lymphatic vessels to prevent spread of the tumor cells during the operation. Papers have been published showing not only positive but also negative results. Therefore the main subjects of investigation have been:

- ☐ Experimental investigations of the use of the CO2 laser compared to the scalpel or electrotome (regarding lymph flow and cancer)
- ☐ Conduction of a prospective controlled study on treatment of breast cancer with or without using the CO2 laser in selected patients
- ☐ Studies on CO2 laser surgery of breast cancer in all patients.
- ☐ The value of using the CO2 laser in patients operated for extensive malignant tumors of the breast.

Experimental results

An experimental study of CO2 laser surgery in mice with Lewis-lung carcinoma (Table 1) was undertaken to find answers to the following questions

- ☐ Can the CO2 laser improve survival in comparison to the conventional scalpel?
- ☐ Is the rate of local recurrence lower?
  Are there morphological findings specific to the applied method?
- ☐ Is there a lower incidence of implantation metastasis?
- ☐ Does the tumor size have any influence on the results?

Table 1: Experimental study of CO2 laser surgery in mice

Procedure	Method		Total number
	Scalpel n	Laser n	315
Excision	107	106	213
Swab test	44	42	86

Table 2: Postoperative tumor formation

Method	Metastases n	cases n	Percentage
Scalpel	37	43	86
Laser	16	42	38

The respective conclusions derived from the study are: CO_2 lasers are not capable of significantly improving overall survival rates with the exception of small tumors, in which case survival rates differ significantly in favor of the laser method (Fig.1). Local recurrence exhibited a lower rate in excision by laser (Fig. 2). Histological and cytological findings reveal tissue and cell damage, contributing to a lower rate of local tumor growth after surgery by the laser technique (Table 2). The incidence of tumor growth was much lower in mice when wounds were exposed to CO_2 laser radiation before swabbing tumor cells into them. Tumor size has a significant influence on results, especially when small tumors are treated by CO_2 laser.

Human surgery

The implications for human surgery are that CO2 lasers are preferable in highly malignant tumors when the excision has to be performed close to the tumor, if the tumor surface is damaged and therefore a risk of implantation metastasis exists.

Results

Prospective, controlled trials on female patients with breast cancer were started in 1981. The criteria for selection of the 135 patients in the study were:

- ☐ Age under 70 years.
- ☐ Clinical tumor stage I or II
- ☐ Pre-or postmenopausal state.

Randomization was done by computer and a radical mastectomy was performed in all patients. Postoperative therapy was standardized according to the hormone receptor state (tamoxifen or other chemotherapy). To date, we have not been able to obtain definitive results because the period of investigation has been too short.

Table 3: Postoperative local recurrence

Procedure	Cases	Recurrence
Lumpectomy	18	6(33%)
Mod.rad.op.	15	6(40%)
Rad. op.	416	20(4.8%)
Total	449	32(7.1%)

Table 4: Postoperative local recurrence after mastectomy (Mo)

Stage	$T_1N_{0\text{-}1}$	$T_2N_{0\,2}$	$T_{3\text{-}5}N_{0\,3}$
Local rec.	3	10	7
No recurrence	156	183	57
Total	159 (2%)	193 (5.2%)	64 (11%)

Follow-up of 449 patients operated for breast cancer between 1975 and 1985 showed a reduced incidence of recurrence only when radical mastectomy had been performed. The recurrence of tumors depended on the kind of procedure used, but it appears that use of the CO2 laser in breast cancer surgery gives an advantage over conventional methods relating to local recurrence (Tables 3,4). Standardized axillary lymph node dissection could not be made by laser, because dissection with laser would endanger axillary vessels or nerves.

Undeniable advantages of the CO2 laser were observed in the excision of extensive tumors of the breast. Our experience of 39 patients with extensive tumors showed the following advantages of laser surgery compared to conventional procedures:

- ☐ Less bleeding
- ☐ Possibility of minimizing excision of skin.
- ☐ Significant reduction of local recurrence.
- ☐ Less postoperative pains.
- ☐ Possibility of primary skin grafting in ulcerated or infected tumors.

Outlook

A definitive statement regarding survival time cannot be made, as the number of patients is too small for a prospective study. Recently, cases of extensive breast cancer have been treated preoperatively by chemotherapy. We found a significant reduction of tumor size in patients responding to preoperative polychemotherapy after three cycles. We hope to prolong the survival of those patients by adopting CO2 laser surgery for the subsequent radical operations. The value of this procedure will be shown within the next few years.

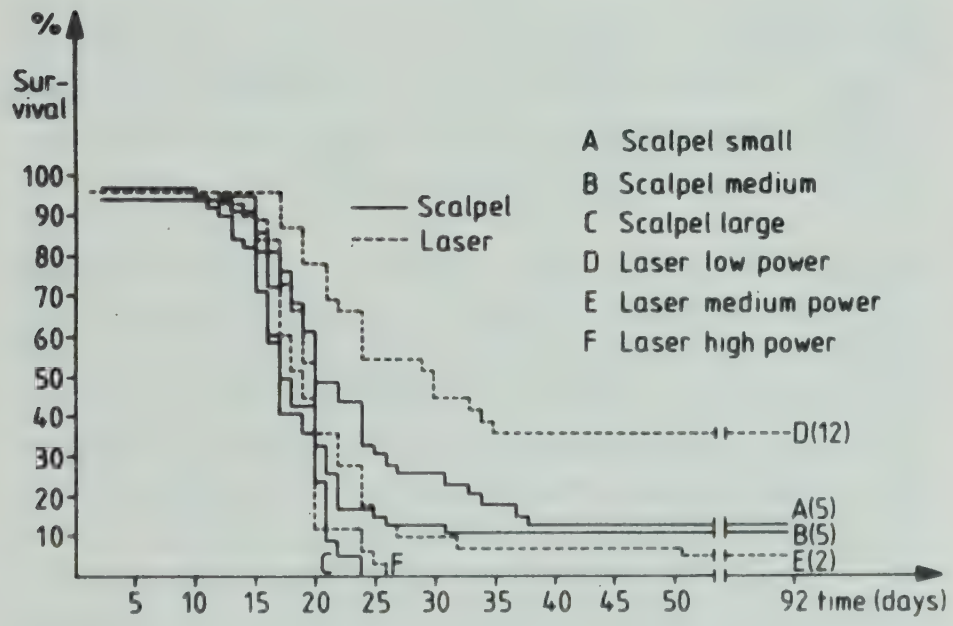

Fig. 1 : Survival after resection with or without laser depending on tumor size

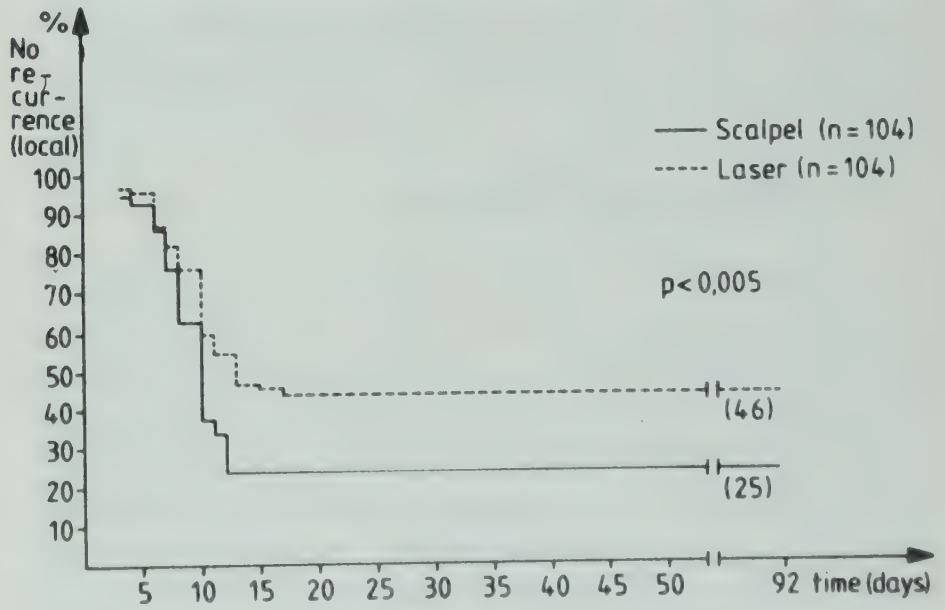

Fig. 2 : Local recurrence rate

Orthopaedics

15. Present and Future Perspectives of Application & Utilization of Modern Technology in Orthopaedics

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I Introduction

Modern medicine has made a quantum jump in the quality of patient care particularly in orthopaedics over the last few decades. These advances have been the outcome of improved methods of diagnosis using newer technology, improvement in surgical techniques and safety of anaesthetic methods. Another significant field of study which has greatly altered the outcome of treatment has been the progress made in the field of biomaterials, required for manufacture of implants to be used in the body.

Progress in orthopaedics has been in the areas of newer methodology of diagnostic techniques, advances in the analysis of various biomechanical aspects of human locomotion and musculoskeletal function, and treatment modalities.

II Diagnostic Methods

The orthopaedic surgeons relied on clinical acumen for diagnosis till the advent of roentgen rays which considerably improved diagnostic ability. For a long time this was the sole method of diagnosis till newer invasive and non-invasive imaging techniques like computerised axial tomography and magnetic resonance imaging came on the scene. Advances in nuclear isotope techniques also helped in identifying many generalised lesions in the skeleton. Biopsy techniques using needle guided biopsy under CAT scan also helped to get tissues which were hitherto inaccessible. Techniques of fluorescent microscopy using various fluorescent markers was used in various metabolic studies of bone. Micro-radiography was used to study the vascularity of bone under physiological and pathological conditions.

1. Radionucleide Bone Scanning

Radionucleide evaluation of skeletal disease has been in use since early '60s but was not popular since, with the then available isotopes, radiation dose to the patient was high and the image was not clear. Introduction of Tc99 in 1971 overcame both the problems (Subramanian et.al.1975). Many more radiopharmaceuticals for bone imaging are available today, but Tc99 remains the most widely used agent since it is cheap and readily available. The mechanism of radiopharmaceutical accumulation occurs in the form of solute transport in bone by the process of diffusion in the Haversian system. These can be bound or directly exchanged components of hydroxy-apatite crystal (Keye et al 1975). In cases where blood flow increases, there is an increased accumulation of bone scanning agent at the affected site. The exact mechanism of bonding with hydroxy-apatite is not known but in clinical terms any hyperaemia or osteoblastic activity would result in an increased deposition of the scanning agent.

Radionucleide bone scanning is useful in day to day clinical practice as well as in research. Clinically relevant uses are in assessment of both primary and metastatic malignant bone tumours, infections, osteonecrosis and occult fractures. For research purposes bone scanning is used in study of calcium kinetics, bone mass measurement and assessment of efficacy of medical treatment in inflammatory arthropathies.

Bone scanning is very effective in assessment of primary malignant bone tumours and to some extent in primary benign tumours also. It will readily reveal extent of tumour in bone, multiple foci of bone involvement, and thereby facilitate accurate staging and pre-operative planning (Gilday, 1977; McNeil,1978;Simon et.al,1980).

Bone scanning is a sensitive method of identification of metastatic deposits in skeleton and is invaluable in assessment of a patient with suspected or known secondaries (Blair et. al.1976; Krishnamurthy et.al.1977; Tofe et.al.1975). It is

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vastly superior to plain radiography in locating areas of bone destruction. As little as 5% change in calcium content can be detected by bone scan whereas an x-ray will not detect an area of bone destruction until 30% calcium has been lost (Charkes et.al.1968). CT and MRI are equally sensitive but cannot be used to map out the whole body which can be rapidly and cheaply done by radioactive bone scanning. In addition to identifying occult and very early metastatic deposits, bone scanning can help in choosing an appropriate and easily accessible metastatic deposit for biopsy. Nowadays complete work up of such patients starts from a bone scan (Thrall,1987).

Radionucleide scanning has dramatically improved the early diagnosis of acute osteomyelitis, thereby reducing the morbidity by prompt treatment (Feigin et.al. 1976; Handmaker, 1976; Maurer,1981). Bone scanning is also useful in differentiating soft tissue infection from osteomyelitis and to some extent in differentiating between a loose body and infected joint replacement prosthesis (Campeau et.al.,McInerney et.al.1978). Its role in chronic osteomyelitis is still not fully investigated; it may provide objective evidence of quiescence of infection. Bone scanning is useful in detection of deep seated infection e.g.discitis; and also unsuspected occult infection. For purpose of investigation of osteomyelitis Ga67 (Tsan,1985) and Indium111 labelled WBC (Thakur et.al.1977) have been found to be more useful but the availability of these isotopes is as yet limited.

Bone scanning is quite accurate in establishing presence or absence of post-traumatic avascular necrosis especially at hip (Bauer et.al.1980'; Meyers et.al.;1977), and in follow-up of treated patients to assess effect of treatment on vascularity of affected bone. Bone scanning for osteonecrosis is of particular interest in evaluation of asymptomatic contralateral hip, in evaluation of high risk patients e.g. divers, transplant recipients and those on long-term steroid therapy.

Bone scanning is useful in diagnosis of suspected fracture (Rosenthall et.al.1979) and stress fracture (Geslien et.al.1976; Wilcox et.al.1977). Radionucleide bone scanning is also invaluable as a screening test in a patient with unexplained pain, since a normal bone scan will exclude all bone disease for which delay in diagnosis can be harmful (Kirchner et.al. 1981). For purposes of research in elucidation of calcium metabolism and evaluation of new drugs in treatment of osteoporosis, calcium kinetic studies and bone mass measurement can be done using radiopharmaceuticals or neutron activation analysis (Dymbling 1971; Heaney,1969; Nelp et.al.1970).

Radionucleide joint scanning is also useful in assessing efficacy of newer drugs in treatment of various arthropathies e.g.rheumatoid arthritis.

2. Magnetic resonance imaging

Magnetic resonance imaging is one of the newer techniques in the rapidly expanding technology of imaging techniques. It is based on the physical principle that images can be created through induced local interactions of hydrogen atoms and was first demonstrated by Leuterbur in 1973. Magnetic resonance imaging gives information at the molecular level and therefore it provides information both about anatomical and physiological changes. It also has another advantage that is does not involve the use of ionizing radiation. Magnetic resonance imaging is useful in the evaluation of soft tissue pathology like tumours, spinal pathology, osteonecrosis of hip, diseases of bone marrow and ligaments.

In the field of orthopaedic surgery the cortical bone and ligaments, and non-articular cartilage produce very little signal but the lack of signal from articular bone enhances the signal from the adjacent tissue; therefore bone marrow produces high signal with much better evaluation. The in vivo activity of the tissue can be evaluated with magnetic resonance spectroscopy. This technique is non invasive and can measure the concentration of phosphate compounds in muscle and osseous structures. Magnetic resonance imaging also provides a non-basic technique for great accuracy in the diagnosis of osteoporosis. Various metabolic diseases also causing alteration in the skeleton are shown up by this technique.

Basically the magnetic resonance imaging was applied for the differentiation of grey and white matter within the central nervous system and thereby helped to diagnose a variety of conditions particularly the demyelinating conditions. It helped in visualising spinal lesions because of the ability to visualise the spinal cord without the need for intrathecal contrast material.

Magnetic resonance imaging is also very useful in the diagnosis of osteonecrosis. Since most infarcts of bone occur in fatty marrow, magnetic resonance imaging can give an early and accu-

rate diagnosis. It has also been useful in the planning of limb surgery in patients with primary malignant tumours of bone. Alteration of blood flow in the major arteries by trauma or embolic phenomenon can also be identified with magnetic resonance imaging. This technique also defines the integrity of muscles, tendon structures, and therefore is of great use in the diagnosis of ligament injuries particularly of the ankle joint.

This technique has progressed rapidly as a non invasive imaging technique. Improvement in spectroscopy, and new pulse sequence developments in soft ware would not only improve the specificity but reduce examination time. (Fitzgerald & Berquist, 1986).

3. Fluorescent microscopy

Proteins, including serum antibodies can be labelled with fluorescent dyes without disturbing their biological and immunological behavior and can be visualized under a fluorescent microscope. Fluorescent dyes can be detected in lower concentrations and have a great microscopical precision. Heidelberger, Kendall & Soo Hoo(1933) and Manach(1934) were the first to produce an antigen tagged with a dye. Riggs Seiwald, Burckhalter, Downs and Metcalf(1958) introduced a simple method using fluorescein isothiocyanate. The principle of fluoroscent antibody method is the application of conjugated specific antiserum to a microscopical preparation containing the antigen. The labelled antibody combines with the antigen and can be visualized by fluorescent microscopy. This fact has been used in the diagnosis of various autoimmune diseases like rheumatoid arthritis. Various workers applying the immuno-fluorescence technique of Coons and Kaplan(1950) have studied the distribution of rheumatiod factor in the tissues of rheumatoid patients. Mellors,Nowoslawski,Karngold and Sangson (1961). Mellors, Heiner, Corcos and Korngold (1959) made a detailed study of the cellular origin of rheumatoid factor and established its presence in the plasma cells.

Fluorescence induced by tetracycline was first reported by Loo et al(1957). Tetracycline given by any route got deposited at the site of new bone formation and it gave golden-yellow fluorescence when undecalcified sections of bone were seen in ultraviolet light. Tetracycline once deposited remains attached to bone till it gets remodelled. These properties of tetracycline have been further confirmed by Urist et al. (1963), and Harris et.al (1964). Tetracycline has been used as an intravital tissue marker for measuring the rate of bone accretion. Frost (1962) termed the deposition of tetracycline as a label and also observed that it got deposited at the zone of demarcation between the mineralized bone and osteoid. The appositional rate of bone growth can be measured by giving two labels of tetracycline. The use of tetracycline fluorescence has been used in the study of various metabolic bone disorders like rickets and osteomalacia (Kelly et.al, 1965 and Heinrich and Ramsag et.al.1966) Vit.D resistant rickets (Frame et.al. 1965) and familial hypophosphataemic Vit.D resistant rickets (Villanueva 1966). This technique can also be used to study the effectiveness of various drugs on the metabolic bone disorders.

4. Micro-radiography

The amount of bone formation and resorption can be studied by micro-radiography very satisfactorily. Micro-radiograph is a black and white portrait in which details of calcified tissues are visible but not of soft tissues and cells. Its density is directly proportional to the amount of minerals in bone tissue (Jowsey,1966). The surfaces of bone which are in the process of formation or resorption have a characteristic appearance and can be recognised by mineral distribution (Jowsey and Kelly, 1965). Newly formed osteons and bone traceulae appear greyish in colour as their mineral content is low. After full mineralization they appear almost white. Areas of bone resorption are recognised as holes with irregular margins surrounding bones of high density. Areas where bone formation and resorption has ended are recognised by the appearance of smooth sclerotic level adjacent to the vascular space. Microradiography cannot determine the linear rates of bone formation and resorption as it is not possible to measure the tissue laid down or removed over a definite time interval(Jowsey 1966). Nevertheless quantitative microradiography is the best method for measuring the bone turnover (Ramussen and Terenhouse 1967) and has been extensively used in various metabolic studies (Jowsy and Kelly; 1965,Lee,1967)

III Biomechanical Analysis of Musculo-Skeletal System

Modern techniques of gait analysis have helped in understanding human locomotion better in normal and pathological states. Although simpler methods were often used, the exact muscle contraction during different phases of gait cycle

were not easily discernible. Modern technology using complex cinematographic equipment, electromyograph and computers were therefore used in the study of human locomotion. Walking is a complex function and its analysis can help in finding a suitable mode of treatment for the pathological gait. The reason for a particular gait pattern can be evaluated by a dynamic EMG and vector analysis. For the effectiveness of the person's gait, energy cost and stride analysis are measured. Motion analysis is by the observational technique of gait analysis which involves systematic assessment of motion pattern of each segment i.e. foot, ankle, knee, hip, pelvis and trunk. For quantitated motion analysis, electrogonimeters are used, which can be fixed to the patient's limb during walking. Automated recordings of the entire limb can be carried out with the help of a videodisk camera and a microcomputer, combined in a single plane system(Gronley and Perry,1984).

Dynamic electromyography is used by recording myoelectric signals generated as a result of neural stimulus. Surface electrodes can be used which determines a gross activity of a group of muscles. The myo-electric signals are transmitted by telemetry for recording and are tested against a normal performance as the reference. This information can be used by the surgeon determining normal/abnormal function for final surgical procedure of tendon transfers.

The amount of effort involved in walking by handicapped individuals can also be measured, thus helping us in choosing the best mode of locomotion for them. Performance data is collected by ECG electrodes for heart rate, thermal sensor for respiratory rate and a foot switch for gait velocity. Expired air is collected in plastic bag for analysis of oxygen or carbon dioxide content. This information can be used for determining the optimum device for the locomotion of the patient.

Study of gait by cinematographic technique using three cameras and projecting them on special viewers have been carried out (Sutherland and Hagy,1972). The movements of various joints of both the extremities can be made and the electromyograms can be superimposed on the motion picture film for simultaneous recording.

IV Computers in Aid of Orthopaedics

Although computers had been invented in early 19th century, it was only in 1960 that the National Library of Medicine applied computer technology for the storing and retrieval of medical literature, for Index Medicus and Excerpta Medica. Today there are over 2453 data bases available, out of which 29 contain information on orthopaedics alone or orthopaedics with other specialities (Williams,1986).

The most important usefulness of computers in orthopaedics is of course for storing or retrieval of medical records (Kuslich and Peck 1986) but its usefulness has been broadened considerably in the hospital. The computer, with its terminals located in the various investigative laboratories can provide instant report of seriously injured patients so that a rational treatment can be planned. All notes including those of the operation can be recorded and stored as data for future use.

The computers have also been found to be of tremendous use in the design of custom-made orthopaedic implants by the use of computer graphics (Bechtold 1986). The practice of using custom-designed orthopaedic implants is becoming increasingly common. Joint replacements are being done in relatively younger patients and smaller prostheses are necessary to fit their medullary canals which may not be available in the stock size of prostheses. Patients requiring revision of prosthesis after a failed arthroplasty or cementless arthroplasty or in excision of bone tumours for limb salvage surgery need a custom-made prosthesis. Computerised tomography is used to quantify an individual femoral cavity geometry. Data in digital form is than used in computer aided design (CAD) programmes to produce instructions for computer-controlled milling machines. Using these techniques it is possible to produce a stem that is custom-designed for each patient. Aldinger et.al.(1983) also used CAT scan to provide data of the medullary canal contour data necessary to manufacture femoral prosthesis using NC techniques. The prostheses so produced, though not totally congruous are closer than standard models and have superior stress and load transmission properties. The Mueller Institute for Biomechanics in Bern-Switzerland and The Hospital for Special Surgery in New York have developed the facility for internal computerized design and developed their own prosthesis. Based on the same principle Simon et.al(1985) have described a method of designing knee prosthesis in three standard sizes.

The basic concept is to provide a numerical data base giving specific details about the prosthesis,

which is stored in the computer and can be changed as necessary to modify the shape and then can be fed to automatic milling machines for manufacture. Many computer-aided designs (CAD) use a simplified two-dimensional drafting type of software that can be extended to three dimensions for viewing purpose.

In case of hip prosthesis, data points from the proximal femoral intramedullary canal can be used to define the B-spline control vertices describing the surface of the intra-medullary canal. An implant can then be designed from this model of the intramedullary canal. Recent advances in computer graphics with terminals of high resolution allow objects to be displayed in great detail (Bechtold 1986).

Apart from its use in prosthetic designing, the computer has proved to be of invaluable help in rationalising data recording, simplifying office procedures (Kuslick and Shorezewski 1986), teaching (Buckwalter 1986) and computer graphic modelling in surgery (Wing,Dvorak and Dvorak 1986).

V Frontiers in Orthopaedic Treatment

Last three decades have completely changed the concepts of orthopaedic treatment. The progress in orthopaedics has been spectacular not only due to the ingenuity of the orthopaedic surgeon but due to the phenomenal progress in the field of science which made these advances possible.

The main thrust of treatment has been on the development of joint replacement surgery which has been possible because of progress in the field of biomaterials for the manufacture of the implants. Modern concept of treatment of fracture by principles of rigid fixation is also dependent on the development of newer implants and instruments.

Biodegradable materials have also been developed for reconstructive surgery of tendons and ligaments. Of late, arthroscopy and arthroscopic surgery of various joints by minimal intervention has also been made possible and refined by the advent of fibre-optic technology.

Recent advances in the field of radiotherapy, adjuvant chemotherapy and advances in custom-made prosthesis has not only improved the prognosis in terms of survival but has made limb salvage possible. The role of microsurgery has expanded considerably in the field of orthopaedics and has made reimplantation of severed digits and limbs possible.

The philosophy of treatment of the orthopaedically handicapped patients has also undergone a sea change. No more is the handicapped considered an object of mercy; the residual abilities of the patient has been harnessed and improved to make him a useful citizen by using modern electronics to amplify the weak potentials of weak muscles.

1. Joint Replacement surgery

Total replacement of joints has become one of the very common reconstructive procedures for relief of pain and improving motion in various arthritic conditions. This surgery has evolved as a result of progress in finding out various acceptable materials for prostheses manufacture, improvement in design and the manufacturing techniques.

The credit for the evolution of this surgery goes to the late Sir John Charnley whose epoch-making work on the use of various materials for the prosthesis and use of acrylic cement for fixation of the acetabular and femoral component in femur remains unsurpassed. John Charnley (1970) popularised the use of acrylic cement for bonding the prosthesis to the bone and prosthesis. Before Charnley's method of low friction arthroplasty, hip prosthesis made of metal upon metal were in use. Charnley was the first one to use high density polyethylene (acetabulum) and metal for (femoral) prosthesis. These two materials were tried for a long time in the laboratory and were shown to have less friction than metal upon metal (Freeman 1975). The use of these two materials was decided after deciding on the frictional resistance, risk of carcinogenesis from wear particles and tissue toxicity. Modern technology has concentrated mainly upon the following areas for the development of joint replacement surgery.

i) Better design of the prosthesis so that it can bear the cyclic loading of the stress better. The computer-aided design for prosthesis manufacture has already been mentioned earlier.

ii) Search for newer material for better biocompatibility, wear resistance and stress-bearing capability.

iii) Newer engineering techniques for increasing the strength, decreasing corrosion, and fatigue fractures.

vi) Improvement in surgical technique and instruments to produce a better fit.

A better understanding of the biomechanics and the anatomy of the various joints, particularly of the hip, resulted in better designs of the hip joints. In the hip joint the stem design, the length of the neck, the size of the head, and the acetabulum, were designed to wear the load per unit surface. Charnley was aware of the problem of friction between the two surfaces of the head and the cup (boundary lubrication). To lessen friction he lined the acetabulum with Teflon and later on reduced the diameter of the head to reduce the resistance by reducing the movement. It is to the credit of Charnley that the basic concept of low friction torque arthroplasty with metal-on-polyurethane has been established as a standard against which other arthroplasties have been evaluated.

Investigations have been made to either do away with the cement, or to produce other designs including a bipolar hip. The bipolar cup was followed by an array of modular systems with various combinations of head and neck sizes. Because of some complications which developed in the stem design, surface replacement arthroplasty came into being to have an anatomical fit of the femoral and acetabular components. It is dependent upon having adequate range of components which are interchangeable and have custom fitting capabilities for better fixation and minimal loss of bone stock.

Various materials have been in use from time to time, viz. stainless steel, cobalt-based alloys and titanium and titanium-based alloys. Porous coated stems were designed for better stress distribution. In addition to porous coating, interest in press-fit stems and cups has also been revived (Bombelli & Mathys,1982). Ceramics are also in use in various centres and are said to have properties of low friction and wear.

Development of joint transplant of joints other than the hip have not been so spectacular; nevertheless progress in their development has not lagged behind. Today the knee, elbow, shoulder, ankle and carpal joints have been replaced with different types of joints and materials. The development of knee replacement has taken place from a compartmental, and condylar to a semi-constrained and constrained knee (Waugh 1983). The consensus seems to be favouring a condylar knee with some in-built constraint.

2. Carbon fibre

Another material that has found a useful application in orthopaedics is carbon. Carbon is used in two forms - vitreous or glassy carbon or filamentous carbon, or carbon fibre. Carbon fibre is manufactured by a complex process in which a fabric polyacrylonitrile (acrilan) is converted into 'ash' without changing the molecular configuration of the original fibre. This fibre is then oxidized at 220° C to make it narrower and its molecules tend to line it up in an axial direction. Heating it upto 3000° C crystalises the carbon into a graphite form. Subsequent oxidation converts it into a thinner but stronger carbon fibre, increasing its tensile strength and making it lighter. This fibre has found a significant clinical application after many experimental trials (Gopalkrishnan, Bhan, and Dave, 1984). Carbon fibre has been extensively used as a substitute or to strengthen tendons and ligaments for their repair. Carbon fibre is infiltrated by vascular tissue from the surrounding vascular tissue and therefore has not been of much use in the repair of ligaments in the knee joints.

Carbon fibre has also been used in the manufacture of plates from graphite fibre reinforced with polymethyl-methacrylate. These plates were used as implants for fixation of fractures with A.O.Cortical screws (McKibbin 1983; Tayton et.al. 1982). Carbon fibre has also been used to reinforce the artificial joints (Lancaster,1968) for repair of hernia (Johnson Nurse and Jenkins, 1980) and used as a nerve graft (Rails et.al.1982) in laboratory conditions.

3. Silicone

Although silicone was discovered at the turn of the century, its medical use started in early sixties only. The polymer dimethyl-polysiloxane is oily but as the polymer chain is made longer it becomes viscous and addition of ferric chloride and oxidation converts it into a rubber like substance called silastic (Helal,1969).

Silicone fluid has been used extensively in medicine as a floating bath for burns, as tissue expander (Wallace, 1960) artificial lenses (Bowen et.al.1962) and even penile prosthesis (Pearman et.al.1967)

In orthopaedics, silastic has been used extensively for wound drainage (Waugh et.al 1961) and for intractable trophic ulcers (Lennox 1965). Its extensive use has been as silastic sheets to wrap around tendon or nerve suture. Silastic rods have been used as a tendon graft as a preliminary to the usual autografts. Today the major

use of silastic has been in the manufacture of implants to be used for replacement of finger joints (Swanson 1966) and carpal bones (Swanson and Yamauchi 1968). Its other use has been in amputation to improve the pressure tolerance of end-bearing below and above knee stumps (Swanson,1966).

4. Arthroscopy

Although arthroscopy was first performed in 1918 by Takagi, it was Masaki Watanabe who performed the first arthroscopic surgery in 1960. An arthroscope is like an endoscope but differs in having an angle of vision at 70 and even at 30 degree to give a wider sweep of vision. The arthroscope carries a glass fibre optic light guide for better visualization (Dandy,1983). The popularization of this technique has led to a much less invasive surgical procedure and enables all the patients to leave hospital on the same day.

5. Electronic system for paralysed patients

The rehabilitation of an orthopaedically handicapped patient due to spinal injury has become a challenge. The paralysed patients have very little muscle function left. These muscle electrical potentials are amplified for control of environmental equipment used in daily living, thereby giving these patients a certain level of independence.

In quadriplegic patients, functional neuromuscular stimulation for restoring movement in the paralysed hand has seen successfully tried (Keith,Peckham, Thrope, Buckett, Stroh and Menger, 1988).

A four-channel percutaneous electrode system with a patient portable external electronic had been used by Keith et.al. (1988). By trial, a relationship is established between movements of contra-lateral shoulder and hand and forearm muscles. In certain cases, stabilization of joint would aid in functional movement. The percutaneous electrodes have some limitations like longevity and infection, and need assistance for fixing them. Functional electrical stimulation has also been used in muscle strengthening and restoration of gait (Kraj, Bajd and Turk 1988; Marsolais and Kobetic, 1988) utilising the patient's preserved function to the maximum. Starting from a two-channel electrode system applied to both quadriceps, a four-channel unit for gait restoration has been developed.

The physiologic effects of functional electrical stimulation in spinal injuries were studied by Rangnarsson (1988). Their studies showed a tremendously improved subjective response of improved well being, feeling of strength and less fatigue. There was an increase of muscle strength and endurance particularly in the quadriceps muscle.

All types of controls of switches, used by the disabled to activate various equipments or systems, use some body function, whether it be minimal movement of body parts or use of vocal, visual and respiratory system. Different types of switches used for this purpose are (1) Microswitch operated by body movements. (2) Capacitance switch operated by body movements; (3) Pneumatic switch operated by breath; (4) Photocell operated by eyes (Ocular movements); (5) Audioswitch - operated by a) Tone or pitch (sounds, whistle), b) Actual voice commands.

Mobility of such patients is a real necessity as it is part of today's culture. Power-driven wheel chairs have been able to provide a considerable amount of independence for the severely disabled. In such chairs the controls are very flexible for quick interchange to right or left and preferably for quick switch from breath,voice etc. These can be manually operated for optimum physical input and are suitable in different locations.

In the field of prosthetics - myoelectrically controlled prosthesis are available especially for the upper limbs. In this system, the electrical potentials generated by the muscle contraction are used to control the externally energized prosthesis. All myoelectrically controlled prostheses utilize a prosthetic hand as the terminal device. Compressed gas has also been used as a power source for upper arm prosthesis using small power in shoulder muscles, or rudimentary limbs in thalidomide babies to open the valve of the cylinder containing compressed gas which provides the power for using the prosthesis.

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16. Present and Future Perspectives of Application and Utilisation of Modern Technology in Orthopaedics

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I Introduction

Orthopaedics, though loosely known as medical science dealing with bones and joints, includes in its field all the living structures that help maintain the upright posture of man and his locomotion. This includes ligaments, muscles, cartilages, bones and joints. Modern orthopaedics encompasses accident and trauma services, surgery of joint replacement, study of back pain, office orthopaedics and other musculoskeletal conditions. With the advent of industrialisation and urbanization, there is increase in the number of road traffic accidents. Trauma care is thus a major responsibility of orthopaedics. It is interesting to learn, that accidents have the dubious distinction of topping the list of causes of unnatural deaths in United States. India, with its fast developing urbanisation is closely following the footsteps of its more developed sister countries.

It would be practically impossible to discuss the full range of applications of modern technology in orthopaedics. An attempt is made here to focus on a few practical applications of certain modern technologies in orthopaedics.

II Diagnostic Orthopaedics: Modern Technologies

1. Computed Tomography

This has revolutionised the diagnosis of spinal diseases. As with any new technique, the levels of technical capabilities very greatly. Yet most clinicians agree that computed tomography is an extremely useful diagnostic tool in the evaluation of spinal diseases. It is an extremely valuable adjunct to the evaluation of cervical spine and the spinal cord. When combined with intrathecal metrizamide enhancement and with computer reformated images in sagittal and coronal planes, computerised tomography is a thorough diagnostic modality that can be applied to congenital or developmental, degenerative and trauma-induced abnormalities. The use of computerised scan is extremely important in the cases of patients with pelvic trauma, usually the sequelae of high velocity road accidents. It should be compulsorily performed on all patients with severe pelvic injuries. It depicts pelvic anatomy in exquisite detail, enabling one to plan therapy on the basis of pathologic anatomy, rather than the presumed mechanism of injury. Computer tomography is more expensive than tomography but gives considerably more information at a lower radiation dose. It is also of considerable value in post-operative follow-up to determine adequacy of fracture reduction and healing.

The most recent advances in technology and computer software have resulted in the ability to reformate the standard axial cuts in almost any direction and magnify the images so that exact measurements of various structures can be made. Specific software is now available to evaluate the density of specific bones and compare it with the normal population. This is a non-invasive, painless, outpatient procedure that supplies enormous information about spinal and other bone diseases.

Computerised arthrotomography provides a more comprehensive evaluation of joints when compared to conventional arthrotomography.

2. Magnetic Resonance Imaging

It is considered to be the newest technological advance in spinal imaging. MRI is a complementary technique to computerised tomography in the examination of the spine, the hip and other musculoskeletal tumors. In some cases it provides diagnostic information not available with any other modality including CT. MRI has a potential to be very useful in the assessment of various marrow-based disorders and may some day obviate the need of contrast aided studies of ligaments, tendons and cartilages.

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Advantages of Magnetic Resonance Imaging

a) Superior soft tissue contrast resolution of MRI relative to that of computerised scan.
b) The ability of MRI to directly image the body in saggital and coronal planes as well as axial planes.
c) The ability to vary the level of contrast between the tissue by manipulating the MRI pulse sequence parameters.
d) The lack of artefacts from beam hardening effects.
e) The capacity to image in the presence of metallic hardware. MRI of musculoskeletal system appears to hold greatest promise in five major areas.

i) Non-invasive imaging of spine and disc disease.
ii) The early detection of osteonecrosis of femoral head.
iii) The evaluation of the extent and tissue characteristics of musculoskeletal tumors.
iv) The assessment of focal and diffuse marrow-replacing processes.
v) The depiction of articular and periarticular structures.

3. Positron Emission Tomography

Positron emission tomography and single photon emission computed tomography are other similar techniques that may offer additional diagnostic information in the near future. It has been reported that single photon emission computed tomography is more sensitive in the identification of symptomatic sites in spondylolisthesis than planar bone scintigraphy.

Other diagnostic tests in finding out spinal diseases are

4. Electromyography: is used in the identification of peripheral neuropathy and diffuse neurological involvement indicative of higher or lower lesions.

5. Somato Sensory Evoked Potential (SSEP): is another diagnostic modality that may identify the level of root involvement.

6. Use of Computers in Orthopaedics

For an effective treatment of the patient what is required is motivation, integrity, interpersonal skills and above all concern for the patients. Of late, computers play an effective role in simulation, analysis and design in orthopaedic surgery. Three-dimensional reconstruction of bony anatomy based on computer tomographic images and radiographs may be used to analyse, simulate and design certain orthopaedic procedures. In osteotomy surgery the computer reconstructed models may be used to measure critical angles, surface area and congruity of joint surfaces. Computer reconstruction may be used in total joint replacement surgery to simulate the effect of surgical reamers and rasps, to select the geometrically optimal standard implant or to design a custom implant. In allograft reconstructive surgery, computer reconstruction may be used to measure bony defects and to identify the appropriate allografts for reconstruction. Plastic models may be sterilised and used to template, to sculpt the allografts immediately pre-operatively. The application of computer-based solid modelling techniques, to human anatomy shows great promise for enhancing surgical instruction and research. Such instruction will directly benefit patient care.

Evaluation of orthopaedic knowledge has and will continue to have an essential part in maintain high standards of orthopaedic education and practice. It is exciting to learn that development of computer-based evaluation methods will provide new potentially important methods of assessing orthopaedic knowledge.

Development of a central computer item bank with appropriate programming for specialised test construction would allow computerised test administration on home computers. The most exciting potential contribution of computers to evaluation of orthopaedic knowledge would be in the development of computer simulations. Computer simulation can closely replicate the process of making a diagnosis, directing treatment or planning and guiding the performance of a procedure, and thereby overcome some limitations of current tests.

Developing methods of measuring student performance on simulations and establishing the validity and reliability of simulations, as evaluation instruments, will require considerable efforts but they offer the promise of providing an important method of assessing orthopaedic knowledge.

We as residents learn medicine with three basic tools-books, clinical practice and above all the desire to learn. Medicine becomes complex because there is much to learn. For the orthopae-

dic resident, biomechanics is a difficult and unpalatable subject. Few residents have previous exposure to these engineering concepts in undergraduate or medical school. Adequate understanding of biomechanical concepts however is fundamental to the practice of orthopaedic surgery. Recently computer aided instruction (CAI) has developed as an effective method of learning. Wide availability and increasing capabilities of the personal computers make computer aided instruction (CAI) more attractive.

Implementation of newly-developed computer modelling techniques and computer graphic display and software have greatly aided the orthopaedic design engineer and physician in creating a custom implant with good academic conformity in a short time. Further advances in computerised design and manufacturing will continue to simplify the development of custom prosthesis and enlarge their niche in joint replacement market.

III Electrical Stimulation for Repair of Bone: Current Concepts

It is currently surmised by many orthopaedic surgeons that electrical stimulation simplifies the treatment of non-union of fractures. It is hypothesized by the advocates of electrical stimulation that there is a delicate interplay between exogenous electrical energy and the complex mechanical, electromechanical and biological processes that naturally occur during the formation of bone. Although internal implantation of electrodes was the first method used in human beings, non-invasive methods were later developed, including the use of inductive coupling and capacitive coupling. With these techniques, time-varying magnetic fields and time-varying electrical fields respectively are used to induce electrical currents at the desired site. Electrical stimulation was first used to enhance healing of bone in patients who had non-union of a fracture or congenital pseudoarthrosis of tibia. Co-operation of the patient is important in the use of all electrical systems. The demonstrated physiological importance of bioelectrical potential has suggested that other pathological conditions could benefit from the controlled clinical application of electrical stimulation. Currently under intense investigation is its use for osteoporosis, osteonecrosis, wound healing, repair of tendons, and ligaments, prostheses that involve ingrowth of bone, fusion procedures, and other clinical disorders. The exact mechanisms by which the various electrical stimuli are thought to induce an osteogenic response are still unknown. Mechanical stresses from the stimulation apparatus itself, chemical electron transfer reactions and biological responses that include modulation of membrane potential and membrane transport are being implicated in the osteogenesis process following electrical stimulations.

IV Advances in Orthopaedics

There has been a remarkable progress in the various fields of orthopaedic surgeries but three most remarkable areas will be discussed. These are arthroplasty, the management of musculoskeletal tumors and arthroscopy.

1. Arthroplasty

Loss of joint function has been recognized since antiquity. Osteoarthritis has been and remains a ubiquitous condition, perhaps genetically determined, resulting in pain, limitation of movements and sometimes. ankylosis of the joint. With advancement in modern technology it is possible to select prosthetic component parts sized to fit the patient, to select a total hip system from a variety of systems, and to use one of several different types of bone cement. A variety of configurations of both femoral and acetabular components parts is available. Currently biological fixation of total joint implants by means of bone ingrowth is the focus of considerable interest amongst orthopaedic surgeons. Many advances have occurred in revisional total joint arthroplasties. After the initial success of polycentric total knee, developed by Frank Gunston of Canada, we now have several designs of constrained, semi-constrained and non-constrained total knee systems. Shoulder, ankle and elbow replacements are also on the cards. Finally, the ability to perform replantation of body parts, made possible by refinement of microsurgical techniques, represents another major advance in adult orthopaedic surgery.

2. Musculoskeletal Tumors

Bone and soft tissue tumors constitute a important and often perplexing problem. Over the past several years, major advances have occurred in the modalities of therapy of bone tumors other than surgery, mainly radiation and adjuvant chemotherapy. Recently, immunological approach to management of bone tumors have been tried. New approaches to the diagnostic system include techniques of biopsy, xeroradiography, skeletal scintigraphy, tomography, peripheral angiogra-

phy, computed axial tomography and magnetic resonance imaging which help in early detection of bone tumors.

3. *Arthroscopy*

In the past three decades, there has occurred a remarkable explosion of interest and technology in regard to arthroscopy and arthroscopic surgery. It has grown from a small subspeciality interest, to a field which occupies much of the attention and time of a practising orthopaedist. It is difficult indeed to divorce this area of knowledge from the parent discipline. Whether in identification of a foreign body or a meniscal tear or diagnosis of unexplained pain in and around the knee, arthroscopy has evolved as a simple semi-invasive technique that comes as a great help to the clinician in solving intricate orthopaedic problems without causing much discomfort to the patient. Its impact has been profound. If one views the broad field of orthopaedics and the many continuing advances, it is clear that its boundaries are virtually limitless and the future is more than promising.

V Conclusion

Orthopaedics as a discipline of surgery has gone a long way in the last 50 years. With increasing research and discoveries of principles of bio-mechanics, this branch will further progress. It is because of modern technology and research that we are developing, designing and fabricating newer locomotor devices like crutches, wheel chairs, calipers and braces. In a country like ours where poliomyelitis is still causing havoc, orthopaedic surgeons are fighting with bare realities to evolve a strategy to eradicate this blot on mankind.

It is also heartening to learn that newer technology is aimed at reducing the patients' stay in wards, early mobilisation, and effective rehabilitation. Much has yet to be done.

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Spinal Chair

Low backache owing to osteoarthrosis, intervertebral disc problems and other orthopaedic problems is a condition that frequently afflicts executives and professionals.

A suitable chair, ergonomically devised to ensure correct posture of the pelvis, is now available. The shape of the seat cushion and adjustable height of the lumbar support ensures this. Other adjustments like adjustable shoulder supports and a swivel column to alter the angle of sitting are also incorporated.

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UROLOGY

17.Present and Future Perspectives of Application of Modern Technology in Urology

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I Introduction

Urology is a branch of medicine which deals with urogenital system in males and urinary system in females. The era of organized urology begian with the formation of the Urology Society in 1886 in France. This was followed by the inception of the Urological Association of America in 1902. The International Society of Urology came into existence in 1910. Historically, the ancient Indian surgeon Sushruta, granted urology the status of a speciality even earlier than Hippocrates, but organised urology started in India as recently as 1961 with the formation of Urological Society of India. With the increase in our aged population, awareness of the people and recent developments in the management of various urological disorders, this branch of medicine has become very important.

Technologies applied to urology include computers, sound, electronics, optics and radiophysics. Advances in imaging techniques like ultrasound, CT Scan, magnetic resonance imaging (MRI), have significantly helped in proper diagnosis. Interventional procedures in urology like endoscopic surgery has replaced a large number of open surgical procedures. Extra corporeal shock wave lithotripsy, percutaneous renal surgery, ureterorenoscopy, renal transplantation, urodynamics, andrology and impotence, microvascular surgery, lasers, are other areas where significant advances have taken place. Computers are also playing an important role in data processing.

II Modern Technology in Urology

1. Endoscopies

There is a constant endeavour in urology to replace open surgery by endoscopic procedures, thereby reducing the morbidity, mortality and hospital stay. Most of the endoscopic procedures are possible as day care. For quality patient care, it is essential to have a complete diagnostic and therapeutic kit. Benign prostatic hyperplasia, carcinoma bladder, stricture urethra, vesical calculi, posterior urethral valves, etc, are various diseases which are now treated endoscopically.

The last decade has also witnessed remarkable development of flexible endoscopes. Most of diagnostic procedures of the lower urinary tract can be done in the office itself without admission of the patient to the hospital.

2. Extra Corporeal Shock Wave Lithotripsy (ESWL)

The ideal of stone disintegration from a distance emerged in the R & D Lab of Dornier of West Germany, interested in manufacturing of supersonic aeroplanes. While studying the harmful effects of supersonic sound waves on solid structures like buildings and other R.C.C. structures the idea emerged. The first machine was installed in Munich in 1980. After that ESWL machines were installed in USA, Europe and UK and then all over the world. The most important limiting factor of this modality is its cost, both initial, maintenance, and replaceable spares. Naturally, in our country we are more concerned about this. Now second generation machines are available, which are cheaper and hopefully in future, new innovations would bring down the cost.

ESWL is a noninvasive technique for management of renal and ureteric calculi. This is suitable for monotherapy only for stones upto 2.5 cms size. If the stone is larger, then PCNL and other auxillary procedures have to be combined with ESWL. Though it is a new technique, this will be the procedure of choice for the management of most of the renal and ureteral calculi. Any good urology centre should have this machine along with facilities for percutaneous nephrolithotripsy (PCNL) and ureteroenoscopy (URS).

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3. Percutaneous Nephrolithotripsy (PCNL) and Ureterorenoscopy (URS)

The first percutaneous nephrostomy was done by Goodwin in 1954. It was only in 1976 that stones were removed through the percutaneous route. Around 1978, the instruments and techniques for PCNL and URS were developed. The renal and upper ureteral stones can be removed by PCNL and lower and mid ureteric stones can be removed by URS. After the advent of ESWL, which is a noninvasive technique, the incidence of PCNL has come down but in the management of large complicated stones, PCNL and ESWL are complimentary to each other.

Flouroscopic imaging is essential for PCNL and URS. Puncture and dilation is done under flouroscopic imaging. The endoscopes are available by which ureteroscopy and ureteroscopic removal of stones have become easier.

The equipment consists of highly specialised urological table with facilities for image intensifier or C-arc flouroscopic imaging with transparent top urological table, TV monitor and ultrasound machines. The cost of the equipment and that of disposables make the procedure expensive initially, but considering the overall advantages of less morbidity, short hospital stay and early return to work, these techniques prove cost-effective in the long run.

About 95% of renal and ureteric stones can be managed by ESWL, PCNL and URS as monotherapy or a combination, and only less than 5% of cases will require open surgery.

4. Renal Transplantation and Haemodialysis

Chronic renal failure can result due to a variety of medical and surgical conditions. If a patient develops chronic renal failure, his life expectancy is limited, unless he is treated by haemodialysis and finally by renal transplantation.

Renal transplantation is a well established operation. In the West, cadaveric donors are acceptable but in our country, only living donors are acceptable. Time has come when 'tissue law' may have to be introduced, so that cadaveric transplants can be done.

The essentials of renal transplant consist of good haemodialysis facilities, tissue matching, meticulous surgery and post-operative care to minimize complications. Rejection is a serious problem but with the use of cyclosporine, the life of graft and patient can be increased. The cost and toxicity of cyclosporine is a prohibitive facor.

5. Male Infertility and Impotence

This field of urology was long neglected due to social taboos. The incidence of the condition was grossly underestimated. On proper investigation, it has been found out that in infertile couples, males can be responsible in upto 40% of cases.

Proper evaluation of infertile male is essential to know whether the cause is medical or surgical. Accordingly treatment is to be instituted. With advances in microsurgical techniques, the results of vasoepididymal anastomosis, vaso-vasal anastomosis and artificial spermatocoele have significantly improved. Operative microscope and microsurgical instruments are essential for proper microvascular surgery.

Proper evaluation of impotency is essential to know whether patient has psychogenic, vascular, endocrinologic or neurologic cause. Nocturnal penile tumescence (NTP), Doppler studies for vascular flow are necessary to know the cause for impotency. After diagnosis,proper treatment is possible. Various type of penile prosthesis, flexible with metal cores, hinges, inflatables with special reservoirs and self-contained inflatables are available. The problems of prosthesis are that in about 30% of cases complications may arise and patient will need a change of prosthesis. Cost is also a prohibitive factor. Medical therapy by injection papaverine and phenotolamine has shown encouraging results.

6. Ultrasonography

This modality of investigation and treatment is not quite new, but it has taken quantum leap in the last decade and has established its place firmly in urology. New generations of equipment for imaging various systems are available. Various modes and two-dimensional sonography has helped in getting excellent pictures of the urinary system. Various special probes have opened new avenues e.g. rectal and urethral probes for details in prostate and bladder pathologies.

Sonography has also helped in localisation of various parts of urinary system with accuracy and thus helped in invasive procedures like renal biopsy, percutaneous nephrostomy(PCN) and tract dilatation, renal cyst and perirenal collections, aspiration, prostatic biopsy, etc. Second

generation ESWL machines have used sonography for localisation of calculi, instead of using image intensifiers.

Ultrasonic waves in other forms have been used for stone disintegration. Various probes have been developed to reach the ureter, renal pelvis and calyces via endoscopes, and, with light contact and ultrasonic wave, disintegration of most calculi is achieved.

7. CAT Scan

Excellent quality of computers assisted tomography (CAT) has contributed to imaging of urinary system, and very small lesions upto 1 cm. size can be detected. It has also helped in accurate staging and treatment of malignancies of G.U. tract and CT guided biopsy is also possible. Ultrasonography and CAT scan are complimentary to each other and have their own indications in various urological diseases.

8. Magnetic Resonance Imaging (MRI)

This is a great advance over CAT scan so far as pinpointing small lesions, mainly neoplastic lesions,is concerned. Absence of radiation is one advantage, but more important is the promise of predicting the malignant nature of the lesion. Here, again cost is a limiting factor in our country. At present, only two machines are available but in the next decade, prices may come down and this could be a commonly available investigation.

9. Radio-Isotope Imaging

The last decade has seen a significant development in radio isotope imaging of the urinary tract. Gamma cameras are available. One can visualize the differential functions of each of the kidneys.

These techniques are useful for diagnosis in obstructive pathology, transplant rejection, vesicoureteral reflux, renal trauma, etc. They are useful in follow-up because radiation exposure is less. The initial cost of the machine is high, but in the long run they are cheaper in comparison to radiologic procedures.

10. Urodynamics

About two decades ago, this entity entered into clinical urology with a big bang. Initially , there was lot of enthusiasm and large number of studies were done in all variety of urological disorders. The proper utility of this machine is now well known. Urodynamic assessment of bladder and urethra is essential in neurovescical dysfunctions for instituting proper treatment. Neurovescical dysfunctions of urinary bladder can result from congenital defects of spine, head injury, cerebrovascular accidents, fracture spine, diabetes mellitus, Parkinson's disease, benign prostatic hyperplasia, etc.

11. Lasers

Lasers have been tried in almost all fields of surgery and urology is not behind others. Various modes of lasers have been used. Initially, it has only replaced the knife, as a much sharper and precise cutting instrument. But laser endoscopic procedures have added to the armamentarium of the urologist in the management of superficial bladder tumours and ureteral tumours. Experiments are being conducted for welding ureters with sutures as in blood vessels and in disintegration of calculi in endourology.

12. Computers

As in other fields of medicine, computers are also used in urology. They are used for recording details in the office, surgical scheduling programmes, maintaining surgical census logs, effective utilisation of medical data-base programmes on microcomputers, slide filing systems, news, letters etc.

To conclude, we should aim that by 2000 A.D. every state should have a well developed centre for urological care and every medical college should have a department of urology.

Every urological centre should have facilities for imaging like ultrasound, CT scan, endoscopic surgery, endourology & ESWL, haemodialysis and renal transplant, urodynamic equipment, uro-oncology, andrology, microvascular surgery, radioisotope imaging, computer, etc. Cost is prohibitive factor and this may appear an uphill task in government sector, but it is possible in the private sector. After the initial cost, the return is faster because of rapid patient turnover, minimum morbidity, short hospital stay and early return to work.

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18. Current State and Future Developments of Noninvasive Treatment of Human Urinary and Biliary Stones with Extracorporeal Shock Wave Lithotripsy: An Update

Gerhard J. Fuchs, M.D. and
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Extracorporeal shock wave lithotripsy (ESWL) has now been in clinical use for seven years and has replaced other treatment techniques of the majority of surgical calculi located in the upper urinary tract.

It provides for the first time a completely noninvasive method for the treatment of renal and ureteral stones. The current range of its indications includes approximately 70% of nonselected urinary stone patients. An additional 25% of patients with more complex stones in the upper urinary tract can receive treatment with the lithotripter ESWL, when combining the method with endourological procedures. More recent additions to the range of clinical applications with the original device, the Dornier Kidney lithotripter ESWL®, have been its use on common bile duct stones in combination with either endosurgical or radiological manipulations, and with a modified Dornier Kidney lithotripter, gallstones have been treated successfully in the past three years. Currently, approximately 30% of gallstone patients are eligible for ESWL treatment.

The principle of noninvasive disintegration of human urinary and biliary calculi has been extensively described.[1-8] The underlying physical principles of shock wave treatment of calculi in the human urinary tract and galltract are: (1) generation of shock waves outside the body; (2) focusing of the shock wave onto an area distant from the generation area and coupling of the shock wave into the body; and (3) localization and positioning of the respective treatment target into the treatment focus. [1-8]

The selective utilization of the destructive potential of shock waves for the disintegration of brittle stone material (whereas surrounding soft tissues are transversed without adverse side effects), constitutes a major breakthrough of modern technology in the medical field. The physical phenomenon that governs the fragmentation of calculi is the rapid build-up of a pressure gradient when shock waves encounter solids of different acoustical properties. The acoustical properties of fluid (degassified water) and most bodily tissues are similar. Therefore, the shock wave transverses these media with minimal loss of energy. The destructive effect of the shock waves occurs when the shock waves encounter materials with different acoustical properties, such as fluid and brittle solids. This creates a strong tensile force in the solid. Mechanical breakdown on the surface of the solid will take place once the tensile force exceeds the solid's comprehensive strength. [1-11]

The first clinical application of this method took place in February of 1980 in Munich, Federal Republic of Germany. In 1983, the Dornier HM 3, the third generation model of the lithotripter, was the first commercially available model, and beginning in 1984 it was distributed worldwide. The major features of this machine include: the water tub with the integrated focusing ellipsoid, the spark plug at the focal point F1 of the ellipsoid (electrically-induced shock wave) and the biplane x-ray system. The patients is positioned on a hydraulically moveable gantry and all functions (EKG-triggered shock wave release, stone localization, and patient movement) are initiated from a central control panel. [1-8]

There is no doubt that ESWL in its original setting, with more than 350,000 successfully performed procedures, has become a most valu-

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able asset to the urologist and greatly benefits urological stone patients (Table 1). During the short period of time elapsed since the introduction of ESWL, the management of urinary stone disease has completely changed, and ESWL has almost completely supplanted open surgical and, to a lesser extent, endourological approaches.[6-8, 12-28] It provides for the first time a completely noninvasive method for the treatment of renal and ureteral stones. The range of its indications has been gradually broadened to finally include approximately 70% of nonselected patients with stones located in the upper urinary tract. (Fig.1) An additional 25% of patients with stones in the upper urinary tract can receive treatment with ESWL lithotripter when combining the method with endourological procedures, such as percutaneous stone removal, percutaneous reconstructive surgery of anatomical alterations (stenosis distal to the stone, precluding proper elimination of disintegrated stone debris), and stone manipulation techniques via the retrograde transurethral route (stone manipulation with stents or ureteroscopy (Fig. 1). [29-34] Clinical experience has shown that only few limitations to the safe and efficient use of ESWL as monotherapy in the treatment of urolithiasis remain. Approximately 70% of patients can receive ESWL alone; more complex stones require auxiliary procedures, namely endourological or open surgery. Those 25-30% of cases, where the combination with endourological or open surgical techniques is advisable, are technically demanding and should be reserved for the stone centers where extensive experience with all alternative techniques of urinary stone treatment exists.

Treatment of common bile duct stones

More recent additions to the range of clinical applications with the original device, the Dornier kidney ESWL lithotripter, have been its use on common bile duct (CBD) stones and with a modified Dornier kidney lithotripter, gallstones have been treated successfully in the past three years. [35-40]

Treatment of CBD stones is performed on the kidney lithotripter and follows the principles established for the treatment of radiolucent stones (administration of contrast dye to visualize the stone as filling defect). The patients are treated in supine position under epidural anesthesia, and more recently analgosedation has been utilized. Indications of the original Munich group were mainly CBD stones after failed endoscopic sphincterotomy.[35,38] More than 100 cases have been successfully performed at 15 centers in a European study group, and in the United States a controlled study involving six centers just recently started. Results of the two groups reporting the largest series (Munich 21 pts., Wuppertal 16 pts.) confirm a similarly high success rate as in the treatment of urinary stones (greater than 80% stone free) and attest to the clinical safety of the procedure. [39,40]

For the treatment of gallstones a modified Dornier HM 3 apparatus has been used successfully on more than 250 patients for over two years now. The modifications include a patient gantry adjusted to accommodate patients in a prone position, which allows the shock wave to enter from the ventral part of the body (less tissue interposed), a generator and focussing ellipsoid with changed characteristics to obviate the need for anesthesia, and a biplane ultrasound system for stone localization. The current selection criteria and the range of indications are depicted in Fig.2. Presently, the investigational treatment protocol limits the number of shock waves to 1600 per treatment session and all patients also receive treatment with ursodeoxycholic and chenodesoxycholic acid for stone dissolution. Experimental studies have proven the increased efficacy of dissolving agents after ESWL has fragmented the stone(s) and increased the overall stone surface accessible to the agent. [37,38] Treatment results of the Munich group (134 pts.) and the Wuppertal group (86 pts.) attest to the efficacy, safety, and clinical reliability of this new and promising method (Table 1). [39,40]

Table 1

ESWL-RESULTS OF URINARY STONES	
• Stone-free at three months	85%
• Spontaneously passable	11%
ESWL-RESULTS OF COMMON BILE DUCT STONES	
• Stone-free at three mmonths	83%
• Spontaneously passable	17%
(Pancreatitis 3%	
ESWL-RESULTS OF GALL STONES (6 months)	
• Stone-free	77%
• Residual	23%
(No major complications)	

Lithotripter hardware changes

In the recent past, clinical trials involving lithotripters other than the Dornier lithotripters have

been performed at a number of centres in Europe, Japan, and the United States. In the following, an attempt is made to assess the current status and future potential of these new devices based on scientific and product information furnished by the various manufacturers (Dornier, Edap, International Biomedics, Medstone, Siemens, Technomed, Wolf, Yashiyoda).

Lithotripters, both the original model, as well as the new experimental devices, have four main features: an energy source, a focusing device, a coupling medium and a stone localization system (Table 2, Figs. 3-6). [9,11,41-52] By now, after seven years of clinical application, the use of shock waves as an appropriate means of contact-free disintegration of urinary stones is well-established. In the original setting,shock waves generated by a spark discharge of a capacitor in a water bath have proven the safety, reliability, and reproducibility of this energy source.

The objectives for the use of alternative energy sources are: equal or better performance and better cost-effectiveness. Basically two different types of energy sources, point sources and extended sources, are being used to generate shock waves. The point sources are the spark plugs (Dornier, Medstone, Technomed), which produce a high voltage discharge-induced shock wave, the laser induced shock wave (International Biomedics), and thirdly, the microexplosive ignition shock wave (Yashiyoda, Fig. 4). Extended sources are the electromagnetic shock wave emitter (EMSE) by Siemens and the piezoelectric shock wave emitter (PESE) by Edap and Wolf (Figs. 4-6) The shock wave sources in the EMSE and the PESE systems basically consist of two conductors with an insulating layer between them, which emit a plane shock wave. IN the case of the EMSE system a magnetic field is established between the two conducting layers, a coil and a metal membrane. Changes of the impulse current to the coil result in movements of the membrane, which induces the shock wave inside the fluid (Fig. 5). The resulting shock wave is focussed onto the target by means of an acoustical lens and is coupled to the surface of the body utilizing a water cushion (Fig. 5). [47] The PESE energy source utilizes a multitude of piezoelectrical plates, instead of the coil and membrane of the EMSE system. An electrical field is established between the conducting layers and the resulting shock waves are propagated through either a water-filled bag (Edap) or a small water basin (Wolf, Fig. 6). [42,48,51,52] Table 2 depicts the basic differences between the spark electrode (Dornier) and various other experimental energy sources, as far as information was made available to the authors. [9,11,41-52]

The currently used spark plug provides an almost constant energy output when the set life span is observed. The experience of all groups operating the Dornier lithotripter attests to the absence of any technical problems with the spark electrode.[10] The microexplosion lithotripter (Yashiyoda) produces shock waves by laser ignition of lead acid pellets, and uses an ellipsoid for focusing with the patient sitting in a partial water bath.[43] Inconstant energy levels at the focal point F2 and a cumbersome x-ray localization technique are the major shortcomings of this device and result in a high number of second sessions and auxillary procedures (Table 3). The EMSE (Siemens) [47] and the PESE (Edap),[46] (Wolf) [42,48,51,52] devices are undergoing first clinical trials in Germany, France, and more recently in other countries. Preliminary results indicate that they are all effective in fragmenting kidney stones. However, the PESE energy sources are not capable of building up the same peak energy levels as the Dornier HM3, which may explain the higher number of second sessions (Tables 2,3).

Ultrasound as a means of stone localization is utilized with the Edap (LT_1010), Technomed (Sonolith 2000) and Wolf (Piezolith 2200) lithotripters.

With the use of sophisticated ultrasound equipment this may offer reduced x-ray exposure and cost savings when used in conjunction with the management of ESWL patients. However, at this point there is still no ultrasound device available that allows the same accuracy of discriminative judgments during the treatment compared to the biplane x-ray system of the original device. Preliminary results of groups, using ultrasound localizing devices who have extensive experience with "conventional" ESWL, are encouraging. [51,52] At this point the problem ares are the unfamiliarity of many lithotripter operators in proper ultrasound interpretation, and ultrasound localization is a time-consuming procedure. Also, a detection of urethral stones and CBD stones is very difficult or even impossible in many cases. This of course limits the range of indication for such a device. Urethral stone and CBD stone treatment are well-established and documented indications for ESWL with the original device. [7,17,18,31,35,36] Similar results were obtained with the Dornier HM 4, [41] the anesthesia-free modified Dornier HM 3. [41,49.50] Experience

with the treatment of ureteral stones exists also with the Siemens device,[47] whereas the ultrasound localization of the PESE and the Technomed devices rules out ureteral stone and CBD stone treatment, or at least makes it a time-consuming procedure with unpredictable outcome.

The next field of development is the generation of the so-called "tubeless lithotripter." In the original device, water has been found to be an ideal coupling medium because its physical properties are similar to those of bodily tissues. [6,7,12] Any device replacing the well-known water-tub should allow for easier patient handling, require less space, and be equally reliable.

The advantage of not having to immerse the patient in water lies in the ease of patient handling and improved passive patient safety by minimizing the hypotensive effect of submersion on the cardiovascular system. Currently, all investigators, including Dornier, are experimenting with tubeless devices or a water basin of reduced size. [9,11,41-52] Certain problems, however, are still not resolved, such as achieving a pressure balance in a closed system. The generation of shock waves in a closed system results in the formation of air bubbles, which in turn imposes problems in achieving effective propagation of the shock waves. A second problem is the difficulty encountered in applying the coupling device to the body. For shock wave coupling to occur without loss of energy it is mandatory that there be no air between the coupling device and the body. Especially in cases of skeletal abnormalities or in patients with percutaneous nephrostomy tubes, this will be hard to accomplish with the nontub devices. [41]

Since the introduction of ESWL several anesthesia techniques have been employed. Most groups utilize regional anaesthesia (epidural catheter anesthesia) and only approximately 25% of users employ general anesthesia routinely. The high frequency jet ventilation technique enjoyed some attraction because the use of this technique may reduce the respiratory excursion and thereby reduce the number of shock waves missing the target. However, the technical difficulty of applying this type of anesthesia and the introduction of effective respiratory trigger devices have made this technique obsolete. Several centers use local infiltration of the skin entry area in an effort to reduce the amount of anesthetic.[53-55] Some of the new devices require much less anesthesia (intravenous sedation and intramuscular analgesics [Dornier HM 4, GM 2, and modified HM 3, Siemens Lithostar]). [41,47,49,50] Other devices even offer the prospect of anesthesia-free shock wave treatment because of the different characteristics of the shock wave at the skin entry site and lower overall energy density. This mainly applies to the piezoelectric devices (Edap, Wolf).[42,46,48,51,52] Clinical trials will have to show the applicability of this concept. Other features of some of the new devices, such as the increased versatility of a multifunctional urological x-ray table (Siemens, Medstone), are mainly of economic relevance; from a clinical standpoint they seem to be compromises.

Lithotripters currently in clinical use are: the Dornier lithotripter HM 3 (watertub); the Dornier lithotripter HM 4 (tubeless version); the modified Dornier HM 3 gallstone lithotripter; and the Dornier lithotripter GM 2, which is specifically dedicated to gallstone treatment (ultrasound localization, anesthesia-free). Furthermore, six more devices recently started first clinical trials (in alphabetical order), the Edap LT 101, the Medstone 1000, the Siemens Lithostar, the technomed Sonolith 2000, the Wolf Piezolith 2200, and the Yashiyoda device. As of July 1987 the Dornier HM 3 (12/1984), in its hospital-based and mobile versions, as well as the Dornier HM 4 have received the Food and Drug Administration (FDA) approval. The Medstone, Siemens, and the Technomed devices have received permission by the FDA to conduct clinical studies to evaluate the safety and efficacy of their devices for the treatment of urinary stones under an Investigational Device Exemption (IDE) at a maximum of six centres in the United States. The installation of the first units just recently started and some centres have already commenced treating patients. The current status and the preliminary results of the clinical trials are depicted in Table 3.

In conclusion, significant efforts and attempts at changing the existing device to improve its performance have been made and some of the preliminary results indeed hold promise for the future. However, these alterations await testing in larger clinical series to establish the same degree of efficacy, safety, and reproducibility as is known for the original devices. More extensive multicenter studies, such as those under the FDA IDE, need to be performed before the routine use of alternative technical concepts for noninvasive disintegration of human urinary and biliary stones can be considered.

All these changes, recent and ongoing, indi-

cate that we certainly have not yet reached the end point of the development of this method and its clinical applications in urology and other medical fields. The future certainly will bring about anesthesia-free ESWL devices, and further improvements in ultrasonography also will result in the development of reliable ultrasound localization systems for biliary and urinary stones.

The different characteristics of future ESWL devices will open totally new aspects in the treatment of urinary and biliary stone disease and,as far as ESWL monotherapy is concerned, many patients can be conveniently treated in an office out-patient setting. Due to the design and working features of the new devices, space and personnel requirements will be greatly reduced and a significant reduction of the cost of consumables is forseeable. [56,57] Anesthesia will still play a role in the treatment of complicated stones, that need combined treatment of any kind, and also in patients who require the use of alternative techniques (endourology, endosurgery).

It is certain that the progress of ESWL represent a dramatic change in the management of urinary stones by which invasive approaches have been superceded by a noninvasive procedure. The preliminary results with the ESWL treatment of biliary stones indicate that in this field similar changes may be foreseeable. Every new development has to be measured against the current standard in ESWL set by a high performance device. As we know from experience it is not an easy task to meet high performance standards, ascertain patient safety and clinical reliability, and at the same time offer improved technical features and better cost-effectiveness.

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Table 2

COMPARISON OF TECHNICAL DATA OF VARIOUS SHOCK WAVE MACHINES

Shock Wave Generator (Focusing Device)	Coupling Medium	Localization (X= X-ray (U=Ultrasound)	Peak Pressure (Bar)	Pain-free Treatment Today	Pain-free Treatment Future	No. of Apllications without change
Spark Gap (HM 3) (Ellipsoid)	Bath	X	50-1500	NO	YES?	1
Spark Gap (HM 4) (Elliposid)	Membrane	X	50-1000	YES	YES	1
Modified Spark Gap (Technomed) (Ellipsoid)	Limited Bath	U,X	?	NO	YES?	?
Microexplosive (Yashiyoda) (Ellipsoid)	Bath	X	0-?	NO	NO	-
Electromagnetic (Siemens) (Lens)	Membrane	X	0-1200	NO	YES?	10?
Piexoelectric (Wolf) (Bowl)	Limited Bath	U	0-800	YES	YES	>10?
Piezoelectric (EDAP) (Bowl)	Membrane	U	0-Max?	YES	YES	?

TABLE 3 **RESULTS OF ESWL FOR URINARY STONES-COMPARISON OF CLINICAL EXPERIENCE OF VARIOUS LITHOTRIPTERS**

Model	Start of clinical use	No. of cases	No. of centres	No. of patients having second session (% of patients)	No. of shock waves (average)	Disintegration % of patients)	Stone-free at 3 months (% of patients)	Auxiliary procedures (% of patients)
Dornier (HM 1,2,3)	Feb. 1980	300,000	270	4-8	1300	99	85	15-20
Dornier HM 4	1985/86	450	2	1-2	1000	99	85	15-20
EDAP	1985/86(?)	175*	12	?	?	90	62	?
Medstone	Sept.1986	<20	2	?	?	?	?	?
Siemens	Feb.1986	>800	4	6	1100	97	?	25
Technomed	1985/86?	161	2	9	1750	87	82	8
Wolf	1986	>1000*	6	17	3000-4000	90	?	?
Yashiyoda	1985	<100	1	30	50-690	75	73	28

* Renal stones only

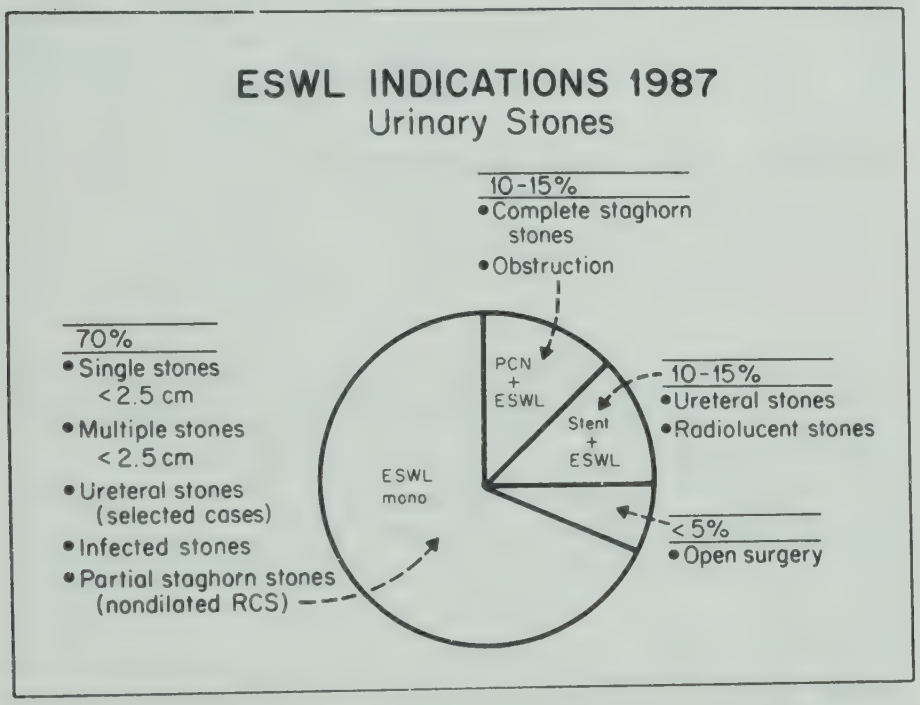

FIG. 1: Current ESWL indications for the treatment of urinary stones.

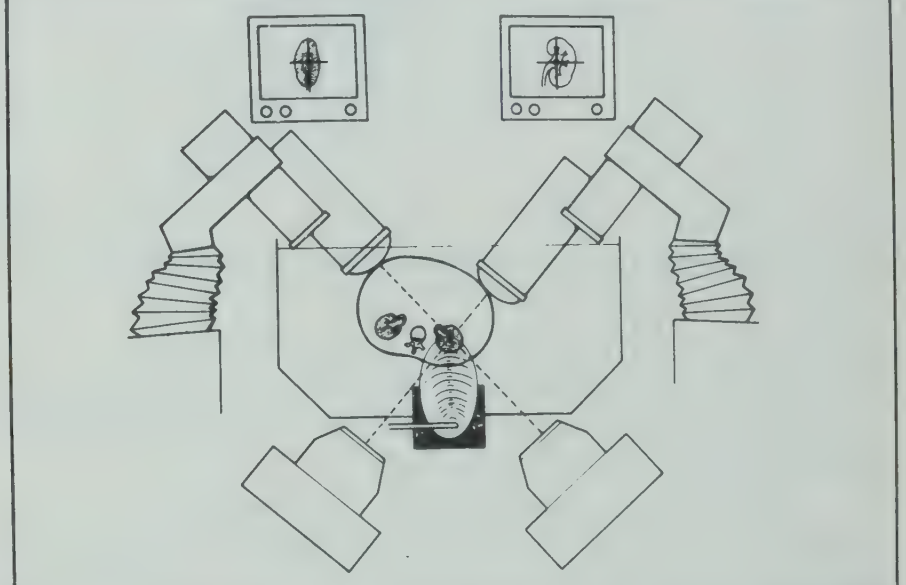

FIG. 3: Schematic drawing of Dornier Lithotripter HM 3 (center: ellipsoidal reflector with shock wave source in focal point F1, stone localized in focal point F2, biplane x-ray system).

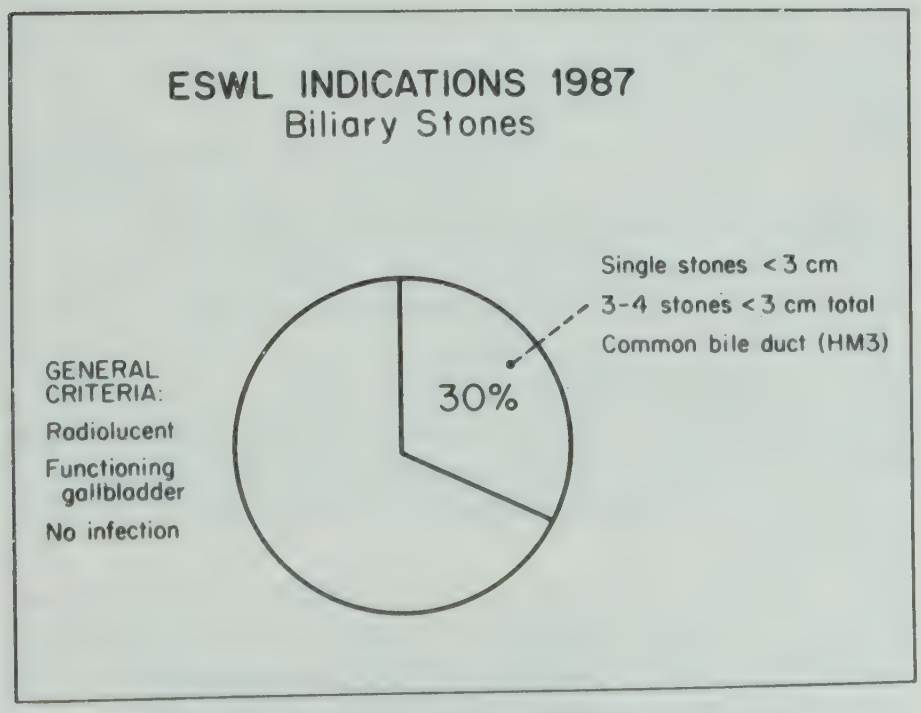

FIG. 2: Current ESWL indications for the treatment of biliary stones.

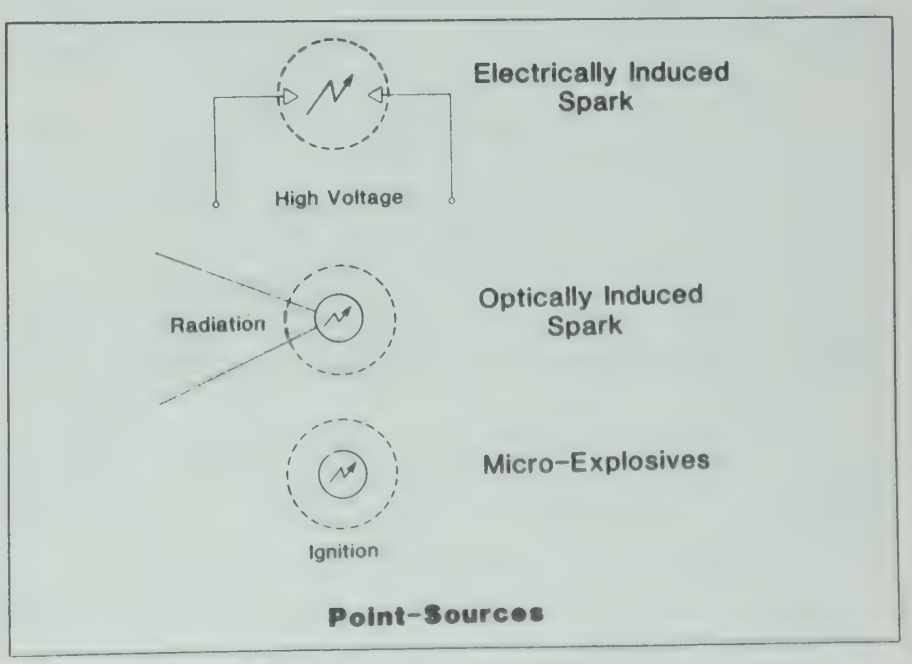

FIG. 4: Schematic drawing of the shock wave emission of spherical and extended energy sources.

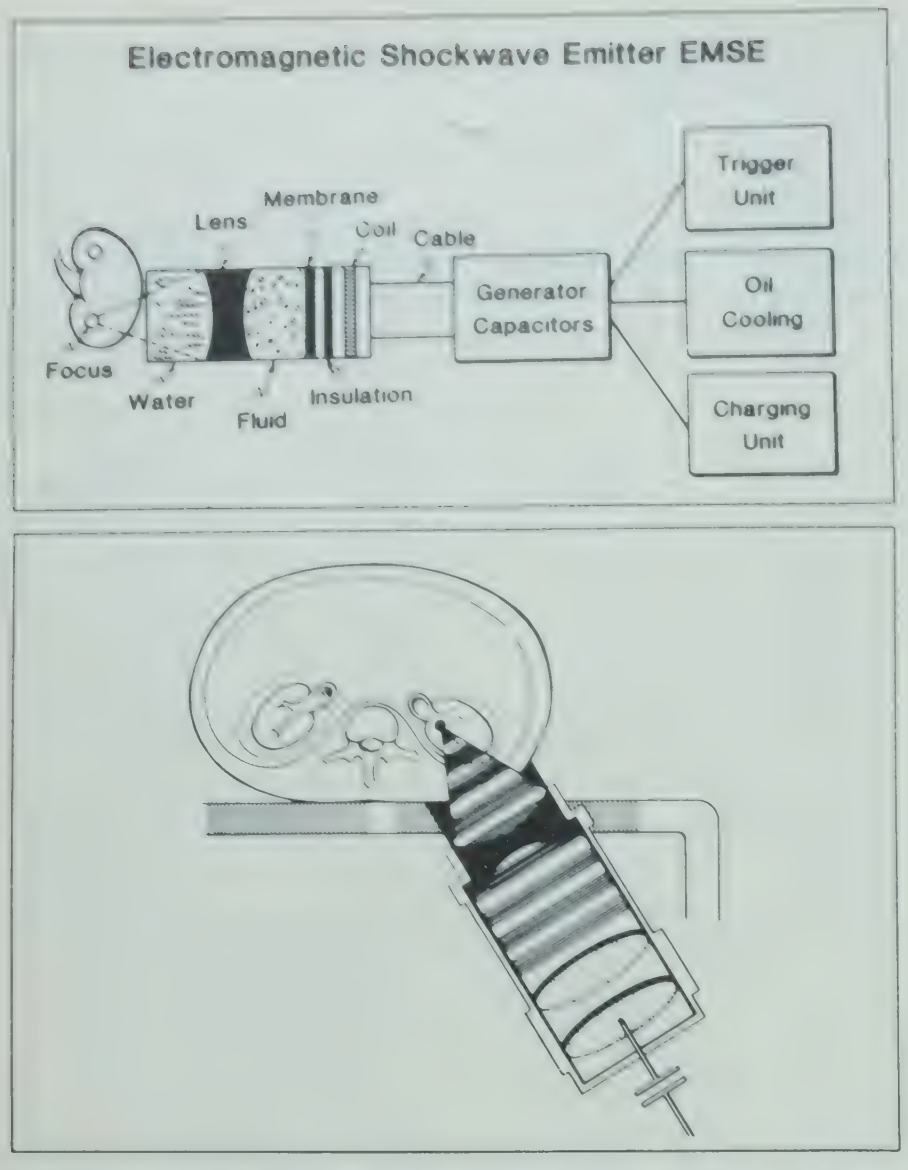

FIG. 5: Schematic drawing of the electromagnetic shock wave emitter-lithotripter (Siemens).

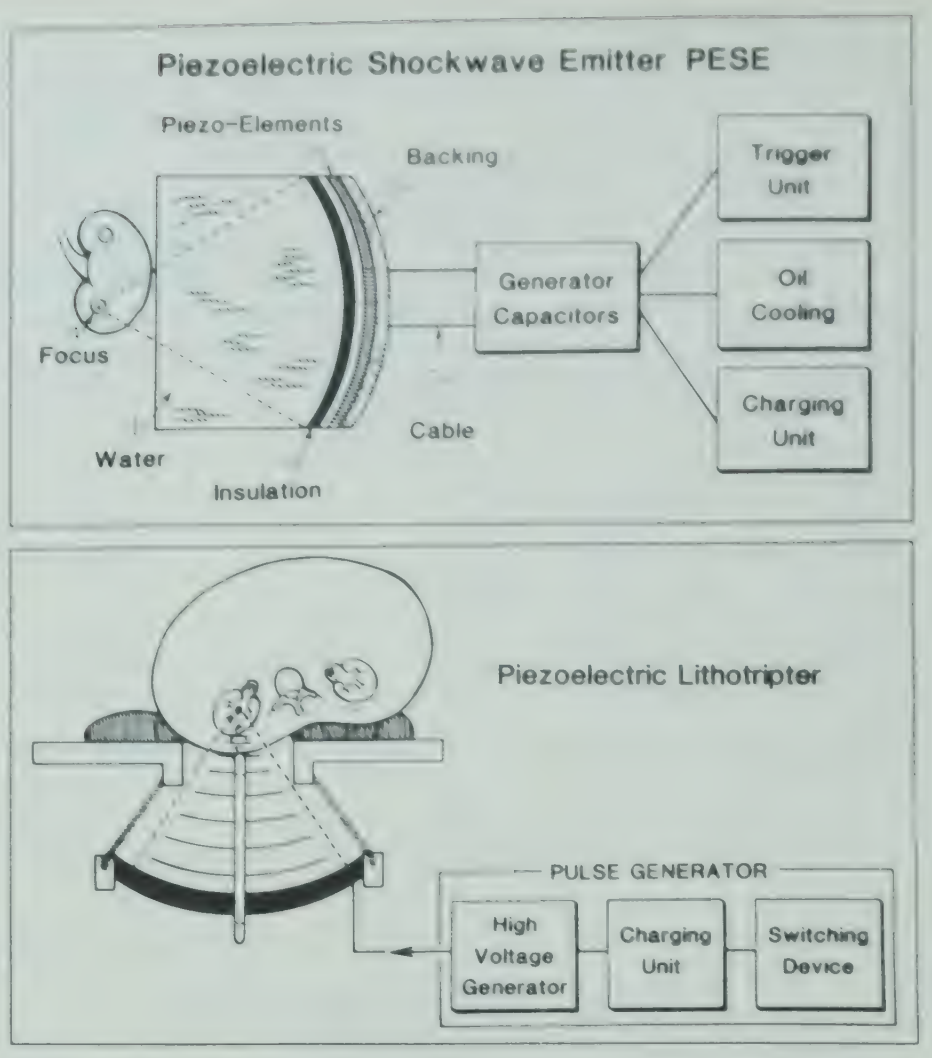

FIG. 6: Schematic drawing of the principle of piezoelectric lithotripters (Edap, Wolf).

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Accident and Emergency Services.

19. Accident and Emergency Services - Modern Concepts

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I Introduction

Trauma is prevalent since the origin of mankind. It is only in the 20th century that the medical services are getting organized for preparedness to salvage human life from accidents and resultant trauma - an outcome of modern civilization. Medical science has always stood up to the challenges since Florence Nightingale tried to organize delivery of medical services during the Crimean war. Mankind in modern times has realized the extent of trauma in case of a nuclear war: the present day newspapers are full of major and minor accidents resulting from a fast pace of modern life.

II Morbidity and Mortality Due to Trauma

Figures of mortality/morbidity are, unfortunately, not available for our country. United States of America, however published that in 1981, trauma was the leading cause of death in the first four decades of life - approximately, 1,50,000 people died due to trauma. The main categories were automobile accidents accounting for 30% followed by gunshot wounds - 22%. The mortality of trauma in 1988 alone is mentioned to be three times the total number of America's combat related deaths in entire 11 years period of Vietnamese war. The total annual cost of dealing with trauma, to American society is estimated to be 88 to 100 billion dollars.

It is expected that the mortality figures for our country would be comparable or most probably more damaging. The cost of trauma care would of course would be much lower, because of non-existent, to, very primitive accident and emergency services.

Deaths due to trauma

It would be necessary to know the mode of death after trauma in relation to the duration of survival of the victims.[2]

A) Immediate deaths:(50%) The nature of injury makes this group non-salvageable. Examples being lacerated brain, ruptured heart or severe asphyxia.

B) Early deaths:(30%) These occur within two hours of injury and the victims are potentially salvageable. Examples are pneumothorax, ruptured liver or spleen, excessive blood loss etc.

C) Late deaths: (20%) These occur within two-three weeks following injury, examples of this group being, sepsis and multiple organ failure syndrome.

III Management of Trauma & Accidents

The management broadly should be considered under the headings of A) Prevention B) Treatment and C) Education.

A) Prevention:- Public education needs to be undertaken on various subjects like use of auto-seat belts, helmets, alcohol and driving, prevention of fire hazard in multistoreyed buildings and similar topics.

B) Treatment:- Immediate management is for the people on the spot. Involvement of all the citizens would be necessary for the scheme. Television is one of the most effective mode of widespread education to the public and should be utilized to a maximum extent. The subsequent treatment should be planned with a scheme of "Accident & Trauma Centres". These need to be equipped with all available medical sophistication provided by modern technology. It needs to be efficiently supported by effective modes of communication and transportation. Details will be discussed later.

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C) Education: Public education in schools, colleges and through media should involve all citizens at all levels of society - mainly directed towards prevention and immediate management of accident and trauma victims.

The medical profession needs seminars and symposia for updating on modern concepts and advances reported in the medical literature.

IV Approaches to Management of Trauma and Accident Victims

The systematic approach to prompt treatment of trauma/accident victims lies in the organization of accident and emergency centres. A network of such centres needs to be established all over the country. The whole management is a team work with a multidisciplinary approach. No single speciality can deal with all the medical problems of trauma. The discipline of anesthesiology however, will have responsibilities in all the phases of trauma management.

Anaesthesiology involvement

(i) Systematic training on the principles and art of resuscitation immediately after the accident/ trauma, to medical personnel, police, firebrigade, ambulance drivers/assitants and in fact to every citizen of the country.
(ii) Prompt resuscitation on arrival to the accident centre/hospital.
(iii) Anaesthesia for various surgical interventions.
(iv) Intensive care management of the critically ill patients providing support to the vital functions.

The other specialities involved are general surgery, neurosurgery, cardio-vascular & thoracic surgery, orthopaedic surgery, neurology and cardiology. The support of radiology, pathology etc. would be required for these medical services.

The sophisticated equipment for the above specialities would be a long list but it must be realized that modern medicine of this nature is an ever increasing expensive commitment and human life can not be valued in rupees or dollars:

The accident/trauma management system can be considered under the following major headings.
(i) Communication network
(ii) Transport system - ground, air (rotary and fixed wing), sea or river line.
(iii) Prehospital therapy
(iv) Trauma registry to collect and record the data
(v) Medical treatment at fully equipped hospital/ centre.

A medical governing board should ensure quality performance.[3] The Americal College of Surgeons[4] defined three levels of trauma care.
Level III: It can review, resuscitate, stabilize and arrange transfer of a casualty to a definite centre of medical care.
Level II: It can review, resuscitate and perform most emergency surgery. It can also provide I.C.U. facilities and provide for long term rehabilitation.
Level I: It has the capability of Level II and in addition, it has a surgeon and an anesthesiologist available round the clock besides a coverage for all the necessary superspecialities like C.T.V.S., neurosurgery, brain unit, spinal and head injury centre.

Thus 70 to 80% of injuries can be managed at level II and III. It is only the very serious and critically ill patients (15-20%) who need to be managed at level I. Although pre-hospital care is important, the approach described above is debated,[5,6] whether critically injured patients should be directly taken to level II & III even when the facilities of Level I are immediately available. It seems reasonable, in our opinion that 'basic life support' (B.L.S) should be provided at the site of accident and continued during transport to level I or II facilities, where 'advanced life support' (A.L.S.) measures could be instituted when necessary.

1. Communication system and network

It is essential that communication from the place of injury to base hospital/trauma centre be highly efficient. In the advanced countries, there is radio contact with walkie talkies, between the team on the spot and the hospital where the patient will be taken eventually. It serves two purposes. a) to guide the personnel on the spot, on immediate management. b) to forewarn the hospital of the arrival of the casualty and the clinical condition, so that the hospital can gear itself for effective management of the injured.

It is not only important that the communication system be present but it should be kept in working condition by regular use or repeated rehearsals if necessary between the various team using it. Nothing serves to highlight this fact more than the recent assassination of our late Prime Minister. Though there was efficient two-

way radio contact between the base hospital and the PM's house, in the ensuing stage of panic, the system was not utilized, so much so that, it was not until the patient was brought to the hospital, that the base system was organized to start its function. Even the special ambulance equipped for the purpose was not used. This was in spite of repeated rehearsals held previously. In the Bhopal gas tragedy, a large number of victims could have been saved with efficient communication system and existence of an accident centre.

A perfect example of an efficient communication network is the medical system prevailing in Australia which has been working effectively over the past three decades. Australia has a peculiar problem of having a very low population in a very large territory. Thus it has far-flung areas where only a small population lives, or perhaps only a single family. The only way of reaching the nearest hospital is by air which can take several hours. Thus it is necessary to impart some amount of basic medical advice by radio to the spot, in order to deal with the injury. These isolated population centres have an efficient method of contacting the nearest hospital by telephone, wireless or T.V with satellite linkages, when the actual scene can be transmitted to the local hospital. It is possible to transmit various data like ECG, chest x-rays almost instantly to the base hospital where the data is analysed and the correct mode of treatment immediately radioed back. Such a system of course tends to be costly but it is definitely very effective. It should certainly be possible in the future to start linking the various rural P.H.C.s. in similar manner to a base hospital to deliver medical care in the remote areas of our country.

2. *Transport System*

Whenever an accident occurs, *various studies* [5,6,7,8] *have shown that the speed of transfer of a patient to the nearest advanced treating centre may be of utmost importance in saving lives and minimizing mortality and morbidity.* In fact, it is perhaps the single most important factor. A study[9] has shown that, following trauma, valuable time is lost in trying to stabilize a patient at the place of injury. The support can never be enough to save the patient. This only reinforces the fact that the victim should be transferred as early as possible to the nearest hospital or a level II or level I facility. The transport system for transfer of trauma victims can again be modified according to the area. Since our country has a range of terrain and geography, basically the transport system can be divided into two broad categories:-

a) For urban areas (b) For rural areas

These two areas can be further subdivided into plain areas, hilly areas or riverine areas. The transport needs and priorities will be different in the above defined areas.

a) For Urban areas

Where roads are good a *motorised ambulance service* may suffice to shift the patient. A road vehicle is good enough to serve a radius of upto perhaps 50 km. from the base hospital. Anything beyond this would require the need of a helicopter. Thus all modern hospital buildings should have facilities for takeoff and landing of such vertical landing and takeoff aircraft. Some times even in urban centres such aircrafts may be needed to by-pass congested traffic lanes. In almost all the rich nations of the world such facilities already exist, and in our country even with the limited financial resources, we have to work towards such a facility by the year 2000 AD.

b) In rural areas

Depending on the areas:-

i) *Motorised ambulances* could be used if roads are available.

ii) If it is a hill area or an area where no roads are available the Vertical Landing and Take Off (V.L.T.O) aircrafts must be used as a necessity.

c) *Motorised launches* could be used if it is a riverine areas.

Further it is emphasized that whatever the mode of transport used, it should be equipped with the various basic life support systems like -

- Ambu bag and oxygen cylinder
- Endotracheal tubes and airways
- Suction machine
- Portable ventilator
- All kind of I.V. fluids
- DC shocker with ECG monitor
- Emergency drugs
- A stretcher or more, particularly to immobilize the patient with spinal injury.

The immediate management may continue while the patient is being transferred . It can be staffed with para-medic or even trained physician if available and provided suitable communication with the base hospital.

3. *Pre-Hospital Therapy*

One of the biggest controversies in the management of A.E.S. is the status of pre-hospital

therapy (P.H.T.). [6,7,8,9,10,11] Nevertheless pre-hospital resuscitation and stabilization of major trauma victims is being increasingly employed. There is a strong school of thought[7] which says that in acute and serious trauma, the patient ought to be transferred immediately to hospital where all facilities exist: otherwise valuable time may be lost which could be critical. In support of this a study by J. Philip et al[6] evaluated 52 consecutive trauma cases in which patients had a blood pressure of less than 100 mm Hg either at the scene or on arrival at the hospital. In all cases, transport time to hospital was less than intravenous establishment time. Thus the benefits of one such emergency manoeuvre such as fluid administration was neutralized by loss of time. Fluid volume infused had little influence on final outcome. A percentage of patients with correctable surgical lesions might have been salvaged, had prompt transport been instituted. They concluded that the manoeuvers in critically injured patient should be minimized to decrease ultimate mortality & morbidity.

Nevertheless where the base hospital is far off some kind of pre-hospital stabilization may be required.

These would include:-

i) Placement of I/V lines
ii) Rapid infusion and use of pneumatic shock garments
iii) Endotracheal intubation with esophageal obturator
iv) Ambu bag ventilation
v) Oxygen therapy by mask
vi) Administration of emergency drugs

In a study of 100 cases of cardiac arrest following trauma Mcswan et al[10] demonstrated that average time for starting an I/V line was 11 minutes. This delay would appear surprising but one must remember the constraints under which a para-medical team works which may contribute to the delay. Para-medics are usually under radio control of emergency department physicians; the resuscitator must assess the patient by examination, then contact the physician for orders. Thus by the time new orders could be sought for, valuable time is lost. Ventilatory management i.e. endotracheal tube insertion may also be problematic in such conditions.

Another recent study [12,13] as evaluated in a series of 158 cases of cardio-pulmonary arrest, demonstrated that placement of esophageal obturator required more than 4 minutes and the device could not be placed in 20% of the cases. Further attempts made could consume time though the salvage rate was less than 4% in the series. Thus each of the above procedures contribute to delay in transfer of victims to the facility where definitive treatment can be started and the delays avoided. Hence it is recommended that in all injuries except the 15% which are critically ill, following guidelines may be followed.

a) If the injury is within 5 to 20 minutes of a major hospital immediate transfer should be carried out.
b) If transport time is going to be more than 30 minutes e.g. in rural areas, then on the spot resuscitation and some form of pre-hospital therapy may be beneficial.
c) In urban areas, while transfer is being effected simultaneous I/V line and ventilation could be established.
d) However the seriously injured patient should be transferred to a level I or II hospital immediately.

4. Hospital Care

After the arrival of the patient in the hospital, the nature of care to be rendered will depend on the condition in which the patient reaches the hospital, and also upon the available medical facilities. In 1976 the "American College of Surgeon's Committee on Trauma[4]" presented optimum guidelines for the care of trauma patients. These have been subsequently updated and revised. The intent of the guidelines is to fulfil the three R's that is to get the Right patient to the Right hospital at the Right time. The guidelines categorized facilities into three levels described earlier. The modern technology must be brought to its full use in the care of patient at all levels. As has been said earlier the difference between level I and level II facilities are minimal.

Another important fact in the pre-hospital care is to determine as to when and where should the patient be taken. In attempts to solve the problem, efforts have been made to categorise[14] patients into Triage according to severity of injury. The three categories are shown in table I.

It is obvious that category I patient will demand highest facilities; if possible they should be taken to the highest level of hospital care available nearby. This will depend upon the availability of transport e.g. if a swift transport like a helicopter is available, then a patient can be straightaway transferred to the level I facility. It is also logical to presume that if rapid transportation

with highly trained para-medics to initiate resuscitation enroute is available, it is best to by-pass the lower levels of care. This can be instrumental in cutting down morbidity and mortality. Table II[5] will support this statement.

After a patient's arrival in the hospital he/she is immediately categorized as in table I and the actual care begun. The management should be started on the good old principles of ABCDE. Before we start description of ABCDE it is imperative to emphasize that the moment a patient arrives in the hospital (A.E.S Centre) the full panorama of modern monitoring techniques should be brought into action. All the possible monitoring should continue alongside the resuscitation and curative efforts.

4.1 Monitoring of Basic Recordings

i) Blood pressure
ii) Pulse rate
iii) Respiratory rate
iv) ECG
v) Charting of Glasgow Coma Scale (G.C.S.)[15]
vi) Complete general physical examination so as to form a basis for future reference.
vii) Full description of all basic injuries.
viii) Blood samples should be drawn immediately for basic lab data while I/V line is being started. If a peripheral vein is not available then a central vein like femoral or jugular should be cannulated

4.2 Advanced monitoring

i) B.P. (a) non-invasive (b) invasive
ii) Pulse oximetry
iii) Capnography
iv) C.V.P.
v) P.C.W.P.
vi) Cardiac output
vii) Temperature monitoring (especially for the very old and very young)
viii) Cerebral Function Monitor (C.F.M.)
ix) Evoked potential
x) Arterial blood gas analysis

Of all the above sophisticated monitoring techniques perhaps the most important would be pulse oximetry as it is easy to setup, non-invasive in nature and can tell us about the actual oxygen delivery to the tissues second by second. With modern technology it is possible to monitor most of the above parameters while patient is being transferred in an ambulance or aircraft and convey the data by telemetry so that immediate instructions for management can be transmitted to the team on the spot.

It will also be fairly evident that all efforts as resuscitation, treatment and monitoring have to continue simultaneously and one should not be at the cost of others.

After arrival of the patient in casualty ward, apart from the above stated Triage method of categorizing patient on the basis of his injuries, various other methods have been devised so as to predict the eventual outcomes. This also helps in better standardization of the actual care to be delivered.

In assessing the severity of illness or injury, the scoring system is essential for improving the results.

(i) Field triage
(ii) Planning, allocating, and evaluation of medical resources
(iii) Assessing the effectiveness of medical care in reducing morbidity and mortality.
(iv) Institutional auditing.

Currently the A.I.S. (Abbreviated Injury Score) [16] and I. S.S. [17] (Injury Severity Scale) is the most widely used anatomic trauma severity index. It will be worthwhile if we can develop something similar along these lines for our country. Then, a standard format could be made out which could be then circulated to all the hospitals, medical centres, and P.H.C.s, so as to enable standardization of trauma countrywide. It will also enable, the actual treating team to arrive at quick management decisions.

4.3 A.I.S. (Abbreviated Injury Scale)

First developed in 1971. For the purpose of scoring, the body is divided into seven main regions.

(i) External
(ii) Head (including Face)
(iii) Neck
(iv) Thorax
(v) Abdomen and pelvis
(vi) Spine
(vii) Extremities

Severity code is as follows:

Minor
Moderate
Serious

Severe
Critical
Maximum injury virtually fatal
Unknown

The information for scoring each particular injury is obtained by consulting the A.I.S dictionary[18].

The A.I.S. is created to describe the individual injury but it soon became evident that it was desirable to have severity scale describing the patient as a whole. Thus evolved the I.S.S. [16] (Injury Severity Scale).

4.4. I.S.S (Injury Severity Scale)

It was developed by Baker et al 1974 to evaluate motor vehicle injury with multiple trauma. He studied a group of 2018 patients and evolved the scale. He made the following observations.

i) Morbidity increases with A.I.S. grade of severe injury
ii) But relationship was not linear
iii) The mortality increased with regular increments when plotted against the square of A.I.S grade (Quadratic relationship) When patient with identical A.I.S. grade for their most severe injury were compared,the injuries in the 2nd or 3rd body regions tended to increase the risk of death.

Including the fourth and fifth more severely injured areas produced no significant increase in the correlations between the total injury severity and mortality. Subsequent to introduction of I.S.S. a number of studies [4,5,6,9,16,17] have shown its utility as a predictor of morbidity/mortality and as a tool of epidemiology studies.

An important addition to the index of severity was the introduction of concept of LD 50[19]. It is defined as a severity of injury that is lethal dose for 50% of the patients. Bull[18] found age dependent relationship and determined that LD 50 was A) I.S.S 40 for 15 to 44 years of age B) 29 for 45 to 60 years of age and C) 20 for 65 and above.

4.5 Technique for scoring I.S.S

The first step is to grade all injuries for a given patient form one to six. According to the part of body affected, I.S.S regions are

(i) Head and neck
(ii) Face
(iii) Chest injuries (including bones and spine)
(iv) Abdomen or pelvis
(v) Injuries to extremities and pelvic girdle
(vi) External injuries including contusions, avulsions, burns lacerations.

When all injuries have been graded ISS code of most severe injury is recorded by ISS score of scoring table. I.S.S. is thus obtained by summarizing the squares of all I.S.S and A.I.S . code in each of the three most severely affected areas Highest I.S.S attainable is 75.

Thus to summarize:

a) Field Triage (Table I) is useful for field categorization of injuries to be used as a guideline for immediate care in the pre-hospital period.

b) The A.I.S. and I.S.S. are useful for evaluation of patients on arrival in the hospital. They are useful as predictors of the ultimate outcome of the injury.

5. Treatment

After a proper assessment has been made and basic monitoring started, it is imperative to start appropriate therapy to the patient. It s good to follow the tested and tried methodology of

A	B	C	D	E
Airway	Breathing	Circulation	Drugs	Electrical Support

The placement of B,C,D, and E after A, does not mean that all cannot be done simultaneously and in fact should be and can be done together. This order is made to provide a rough guideline, because unless the airway is secured and breathing stated, no matter what one does with C,D, E it is not of any use. Oxygen delivery to the tissues has to be established. Hence the importance of AB being placed first.

A) *Airway control* will depend upon the status in which the patient arrives. For example if the patient already has an endotracheal tube in situ, the patient is straightaway connected to a ventilator. The airway assumes utmost importance especially in the following patients-i) unconscious, ii) head injury, iii) with severe maxillofacial injury, iv) in severe cervical injury v) with severe chest injury.

All the above patients will require intubation

immediately. This will be followed by:-

B) *Breathing* - with ambu bag
mouth to tube
mouth to mouth
with ventilator

Both A and B help to improve delivery of oxygen to tissues, decrease carbondioxide level and diminish acidosis. All this is especially important as proper oxygenation is important for the long term survival and prevention of damage to the vital organs and to improve the viability of the patient.

(C) *Circulation*

(i) Start of large bore I/V line, and multiple lines if I.S.S. is high.
(ii) I.J.V. or cephalic vein for C.V.P.
(iii) Insert P.C.W.P. catheter
(iv) Start fluid therapy with either colloids or crystalloids
(v) Start arterial line - Radial or femoral
(vi) Blood transfusion especially in extremes of age.
(vii) I.A.B.P. to be inserted (Intra Aortic Balloon Pump), if necessary.
(viii) External cardiac compression (E.C.C.) if cardiac arrest has occured.

D) *Drugs*

i) Adrenaline
ii) Vasopressors - Dopamine
- Dobutamine
- Isoprenaline

iii) Calcium
iv) Steriod shock pack - 100 mg of decadron
1000 mg of hydro-cortisone
v) 2000 mg of Methyl prednisolone
vi) Xylocard for any ventricular arrhythmia. Specific drugs for specific problems e.g. morphine for pulmonary edema, digoxin for C.H.F and hyperbaric oxygen for carbon monoxide poisoning.

E) *Electrical support*

(a) D.C. shock- external 2 joules per kg. internal maximum 45 joules.

(b) *Cardiac pacing*

The last resort in the event of cardiac arrest after the basic life support measures fail to resuscitate, is to start internal cardiac compression. In a major hospital setting this can be life saving and must be resorted to. After the patient has been revived, he can be shifted to the operation theatre for treatment of specific injuries.

But in the event of a very severe injury i.e. I.S.S. of beyond 50 it may be prudent to take the patient straight to the operation theater so that no time is wasted and the B.L.S can continue along with specific surgical measures.

V Conclusions

Summarizing modern concepts of accident/ trauma, it could be concluded:-

Centralized Accidents & Trauma Services should be developed to deal with the increasing number of cases of accidents and injuries. The need to have such service should be considered as national health service priority keeping in view that:

- 50 percent of all categories of accident cases admitted are due to traffic accidents.
- There is no organisation efficient enough to deal with these large number of injuries and accident cases.
- The hospital beds are inadequate to deal with this vast problem.
- An efficient transport system to lift these patients from the scene of accident does not exist.
- It has been realized that the most efficient treatment of accident cases should start from the scene of accident itself.

It is essential to have-

i) An efficient communication system.
ii) Speedy transportation of the accident victims for immediate first aid and resuscitation, starting from the place of accident.
iii) Co-ordination and harmonious working with the other hospitals, especially identified for this purpose.
iv) A multi-disciplinary approch for the treatment of poly-trauma cases involving all the surgical and medical disciplines.

Table I: Field Categorization of Trauma Patients*

System	Category 1	Category 2	Category 3
Soft tissue	Avulsion injuries, severe uncontrolled bleeding	Soft tissue injuries stabilized bleeding	Soft tissue injuries of moderate degree
Fractures	Open fractures, pelvic fractures, severe maxillofacial injuries	Single open or closed fractures	Uncomplicated fractures
Abdomen	Blunt or penetrating abdominal injuries, especially when associated with hypotension	Blunt abdominal or penetrating trauma not producing hypotension	No abdominal injuries
Chest	Unstable chest injuries respiratory rate above 30 or below 10	Multiple rib fractures without flailed segments; respiratory rate above 20 or below 10	No respiratory distress, respiratory rate 10-20
Head and neck, upper respiratory	Severe maxillofacial injuries; open penetrating and blunt trauma to face, neck, and cervical spine; multiple facial fractures and injuries affecting vision	Facial trauma with single facial fracture, (without airway or major cervical vascular or cervical spine involvement)	Simple contusions of the head and neck, nasal fractures
Neurological	Prolonged loss of consciousness, posturing, lateralizing signs, open cranial injuries, paralysis	Transient loss of consciousness,oriented to time, place and person	No neurological injuries
Vital signs	BP below 90 systolic, Pulse above 100 or below 60, skin cold, ashen pale	BP above 90 systolic, Pulse 60-100, skin warm to slightly cool	BP above 100 systolic, P-60-100 skin dry and warm

* *From the Bulletin of the American College of Surgeons, February 1980, p.29.*

Table II: *Relation of Mortality to Time Interval Between Injury and Treatment.*

Conflict	Interval(Hrs.)	Mortality(%)
World War I	12-18	8.5
World War II	6-12	5.8
Korean War	2-4	2.4
Vietnam War	1-4	1-7

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Computers and Information Management In Health Care

20. Computers in Hospital Management

*Vipul Jain**

I Introduction

Computers in health care are well accepted the world over, as clinical and diagnostic aids, to improve patient care, tone up administration, facilitate accounting and enable effective management control. An important application has been in hospital management, where computers have been an effective tool for doctors, nurses, administration and management alike.

Computer-Aided Hospital Management is a relatively new area in our country. There have been a few attempts at computerising accounts, billing or medical records as off-line, stand alone applications. Perhaps the first integrated Hospital Management system operationally successful was at the Breach Candy Hospital , Bombay in 1985. Subsequently many hospitals like the Cumballa Hill Hospital, Sir Harkissondas Nurrotamdas Hospital, Jaslok Hospital in Bombay, Kasturba Hospital in Manipal and the Apollo Hospital in Madras have gone in for computerisation. Others like AIIMS and Escorts Heart Research Institute in Delhi are in the process of experimentation with hospital computerisation. Probably the first hospital in the country to go for total computerisation including patient care management will be the Kothari Hospital in Calcutta.

From these varied experiences, two themes clearly emerge firstly, successful computerisation can yield many tangible benefits to hospital management, and secondly, the process of computerisation is complex and requires considerable preparation and specialist expertise. Given the universal trend of falling prices of computer equipment and the emergence of excellent software, specially designed for hospitals, there is no doubt that in the next few years we will see a major wave of computerisation in the health care sector. In this article we will briefly cover some of the typical problems, application areas, benefits and the steps involved in hospital computerisation.

II Some Typical Problem Areas

A research survey amongst hospitals reveals some interesting areas where computers can help.

* Medical directors spend undue time and attention in managing routine administrative chores, leaving inadequate time to solve medical and clinical problems.

* Hospitals lose between 2-5% of their revenue from paying patients because of services/materials not being correctly billed. This in turn reflected adversely on their ability to provide free services.

* Pilferages aside. hospitals can reduce their expenditure on drugs, medical supplies, test kits, x-ray films etc, by atleast 5 - 10% by proper inventory controls.

* Costly medical equipment is often underutilised or even unused because of inadequate monitoring of maintenance and capacity utilization.

* Nursing care can be very much facilitated if paperwork is reduced, test, drug and diet requisitions are automatic and up-to-date patient data is available.

* Medical audit, epidemiological analysis, community surveys and medical education and research are areas where major improvement can result if patient medical records are computerised.

* Majority of patient complaints are related to the administrative efficiency in the hospital.

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Coping as best as we can, these problems remain in degrees that vary from hospital to hospital. The root of these lie in the very nature of the hospital environment -24 hour high volume of data, dynamic nature of information, and very large number of people involved in different departments.

Certainly, computers with their intrinsic power can play a major role in this situation. Computers can act as a communication link between departments and allows the common database to be shared by them. The computer can manage the complex task of securing the data as required. Well-designed, integrated computer systems can be a great tool in the hands of the hospital management in improving services, controlling cost and ensuring optimal utilisation of facilities.

III Computer- Aided Hospital Management system

Typically a minicomputer is installed in the hospital, with terminals in various departments of the hospital like Admissions, Billing, OPD, Pathlab, Radiology, Pharmacy, OT and Finance and Administration. If patient care management is also to be computerised, terminals are installed at the ward nurse stations and medical record sections also. The size and capacity of the computer would depend on the size and workload in the hospital.

The terminals or workstations are used by the concerned staff in the department to carry out various functions. Like an airline system, the Hospital Management System is real-time i.e., information is up-to-date at all time. The workstation is used for all routine work-admitting patients, preparing bills, test results, nursing plans, etc. The system is very easy to use and can be used by clerks, nurses, technicians and other hospital staff with some simple operating instructions.

The computerised system maintains a single, common database for the entire hospital. Thus there is no duplication of work and all transcription errors are automatically eliminated. Being integrated, the system acts like a communication channel in the hospital, routing messages and patient data wherever required.

It is likely that the entire computerisation project is not implemented in one stage, but in phases. To enable this phased computerisation, it is essential that the system is designed modularly, with each module providing full integration with other areas. Such modular and integrated design cannot be an afterthought, but must be planned right from the beginning. The schematic in fig.1 shows a total hospital information system and the various modules are described below.

1. Admission/Transfer/Discharge System

This module provides the base for the In-patient Management System. It handles bookings, admissions, transfers and discharges of patients in the hospital, thereby making available accurate patient and bed census. The system permits patients to be preadmitted as far in advance as the hospital desires. The system automatically keeps control of bed availability. The admission process is handled totally on the computer including bed allocation procedures. Any changes in the patient census, like transfer,births, deaths or discharges are immediately reflected in the system.

The ADT system provides for a variety of patient related information in enquiry form. These are available either hospital-wide or for specific nursing locations. These provide for efficient bed management, proper routing of test results and messages, accurate point-of-service charging, timely patient statistics and related census information for both doctors and management.

2. Patient Billing System

This module caters to all the functions relating to patient billing, cashiering and accounting. Not only are patients kept up-to-date at all times but collections can be tallied and all requisite accounting records automatically produced.

The system includes facilities like deposit handling,autoposting of bed charges,doctors fee accounting, etc. A complete audit trial is maintained including the time,location,ID and voucher details. If the diagnostic lab, pharmacy or OT modules are installed, the charges to patient bills may be automatically raised at those areas with full integration to the patient billing system.

3. Nurse Station System

The nurse station system envisages terminals located in each ward for patient care management. The heart of the system is its capability to man-

age nursing care instructions. Test requisitions dietary requirements, drug administration schedules and other related orders can be entered into the system, either in the form of standing instructions or for a specific future date and time. The orders are communicated to concerned departments, and also scheduled to provide for nursing plans. Control over unexecuted orders ensures their timely compliance.

4. In-Patient Medical Records

This module enables the hospital to maintain patient medical records and retrieves them quickly and efficiently.

The medical record includes demographic data, WHO disease and procedure codes and the discharge summary. The reference to patient file by name, registration no. and admission date is maintained for quick retrieval. The system also provides for a variety of statistical reports to aid research and planning.

5. Investigative Labs

This module caters to the activities of the pathology, radiology and other diagnostic facilities in the hospital. It enables tests to be requisitioned billed and thereafter results to be printed. Test results reporting provide for over 250 different formats, which can be customised by the hospital itself. Management reports include summary statistics on tests done on daily/monthly basis.

This module integrates fully with both the on-patient management modules as also out-patient department.

6. Pharmacy Management

This module manages the billing, cashiering and stock control functions of the pharmacy. Integration with on-patient management provides a look up facility for patient information, drug requisitions and simultaneous posting to patient bills for pharmacy charges.

The system automatically manages stock accounting, controls expiry dates and even prepares purchase advices based on preset reorder levels. It enables hospitals to offer drug facilities to its inpatients while ensuring a smooth, trouble free and profitable centre.

7. Operation Theaters

This subsystem is designed to facilitate the booking and scheduling of OT's and billing for operations including charges for materials and supplies used. Operation theaters can be blocked for any future date for a scheduled surgical procedure. The system automatically keeps track of availability of theatre facilities. Operation charges are posted onto the patient bill apart from providing departmental summaries.

8. OPD Registration

With this module all OPD patients are registered and allotted an OPD registration number. Visits to doctors, labs and other facilities can be scheduled centrally. This module also serves to provide a base for out patient management including medical records and billing.

9. OPD Billing

Out-patients can be billed for doctor's consultation, tests done and other services that are availed. These bills can be settled either completely or even carried forward for multiple-visit package treatments.

10. OPD Medical Records

The OPD Medical Records module helps manage the patient history built up during multiple visits to the hospital. The symptoms, investigations and treatment notes can be preserved for each visit to build up a case paper. Diagnosis-wise analysis, and epidemiological studies, are some of the potential uses of the patient data thus collated.

11. Revenue Audit

The charges raised at various departments are brought together to form a consolidated daily revenue trial balance for the hospital. Audit and revenue controls can be easily and effortlessly implemented to ensure that there are no revenue losses. Patients' outstanding balances, deposit control balances, and daily cash collections are reconciled on a daily basis.

The module also enables costing of services to free patients. It completely eliminates late charges, accounting and audit problems.

12. Medical Superintendant's MIS

This module is specially designed to provide the management of the hospital with key indicators to review the progress. Revenue, departmental contributions, occupancy statistics, capacity ut-

ilization of various facilities, doctor's contribution, stocks and supplies statements are some of the important areas included to form a concise, accurate and timely management information system.

13. Financial Accounting

The Financial Accounting module covers the general ledger system along with debters and creditor's subsidiary ledgers. It provides for consolidation of revenue from the 'front officer' system and automatic posting into the customer accounts for credit or insurance claims. Features for preparation of departmental revenue/expenditure statements, budgetary control reports, statement of accounts, balance reports etc. make this a powerful accounting and financial control tool.

14. Purchase And Inventory Control

This module streamlines the purchase and stores control in the hospital. Linen, kitchen, medical supplies, consumables, spares and other stores items can be handled by this powerful subsystem. Placement of purchase orders, follow up for deliveries, stock control and accounting, ABC analysis and other such functions can be conveniently and smoothly carried out. Wastages, spoilage, and leakages can be eliminated and better prices obtained through timely and planned purchase management.

15. Payroll

This module computerises the employee payroll accounting for the hospital. It caters to the laborious task of preparing payslips, cash/bank statements, payroll summary, departmental summaries and other related documentation. The system also handles the accounting of Provident Fund contributions, employees' loans and other welfare schemes at the hospital.

16. Equipment Maintenance

Hospitals have many costly medical equipment and monitoring their maintenance is critical to providing health care services This module provides for management of warranty and post-warranty contracts, and both breakdown and preventive maintenance. The system keeps the management informed about equipment down, action being taken and followup required. It generates up-time statistics to facilitate discussion with vendors and evaluation of equipment and services. It also monitors the status of critical spares so that the hospital is well equipped to keep its scarce resources fully utilized.

IV Benefits-Summary

* *Efficient Administrative Procedures*

HMS streamlines and reduces administrative workload right through the hospital. Duplication of effort, errors, delays are very much reduced in all departments leading to efficient work methods.

* *Better Patient Service*

Administrative efficiency, timely test results preparation, better nursing care and effective medical audit all add upto better service to patients. The impact is visible in all areas of interaction with the hospital.

* *Control of Costs*

HMS provides a way to control pilferages and wastages of lab supplies, drugs and other material very effectively. Up to date departmental revenue/expenditure statements lead to timely management control on overheads. There is also a definite reduction in administrative / clerical staff required in the hospital.

* *Better Utilization of Facilities*

Bed management and allocation procedures, scheduling of facilities and monitoring of equipment, maintenance, are contributory factors to better utilization of facilities. Further, timely statistics help in better planning, costing and direction to achieve optimal return on resources.

* *Elimination of Revenue Losses*

Being service oriented, it is essential that revenue from paying patients in not lost to the hospital due to errors. HMS provides a way to eliminate revenue losses and audit revenue on a day-to-day basis.

* *Better Nursing Care*

The nurse-station module, reduces the paper work to be maintained by nursing staff while providing an infallible communication system to service departments. Thus any

oversight, transcription errors or delays in requisitions are avoided. Further, scheduling and preparation of nursing plans is greatly facilitated.

* *Meaningful Medical Audit and Research*

Comprehensive medical records are a valuable resource for medical audit and research. HMS helps the hospital maintain its high medical standards and attract the best talent.

* *Informed Management Action*

HMS keeps the hospital administrator totally informed so that he can manage the hospital better-information that helps plan, control and direct the future of the hospital.

V *Implementing Computerisation*

Since computerisation in the hospital affects the day to day functioning of each department in the hospital it needs to be carefully planned and meticulously executed. Some pointers on the road to successful computerisation are given below:

The major components in any computerisation project are:

1. The hardware, i.e. the computer equipment

2. The application software, i.e. the programmed set of instructions suitable for hospital applications.

3. Projects Management and support services

Very few hospitals would be able to implement the integrated hospital management without the services of external consultants. The reason for this is simple-development of the software is a time consuming and costly process and requires in depth computer expertise. The effort for developing a comprehensive integrated hospital management system is about 25-30 man years which means hiring and maintaining a large team of computer professionals apart from the cost of doing so.

The first step is to choose the best computer consultant for the project. Important Criteria to be kept inmind are:

1. The consultant must have expertise and experience in hospital computerisation. Being a specialised and complex area, experience in other areas of computerisation is not easily transferable. In discussions with the consultant, his knowledge of the hospital requirements will emerge very clearly.

2. It is very much desirable if the consultant has a ready-made software package for hospitals. This will save time and cost

3. To qualify as a package that may suit the needs, the software must be running in atleast two hospitals for minimum six months. The hospital administrator should insist on visiting the hospitals and talking to the various levels of staff to see how they feel about the computer system.

4. The consultant must have a proven track record and reputation for quality and service. The hospital administrator should talk to some clients, particularly some first-time users and find out if the consultant gave them proper training, advice and total support.

5. It is necessary to check if the consultant is willing to take total responsibility for the project, including solving any hardware problems, training staff, design of forms and procedures, implementation support and software maintenance.

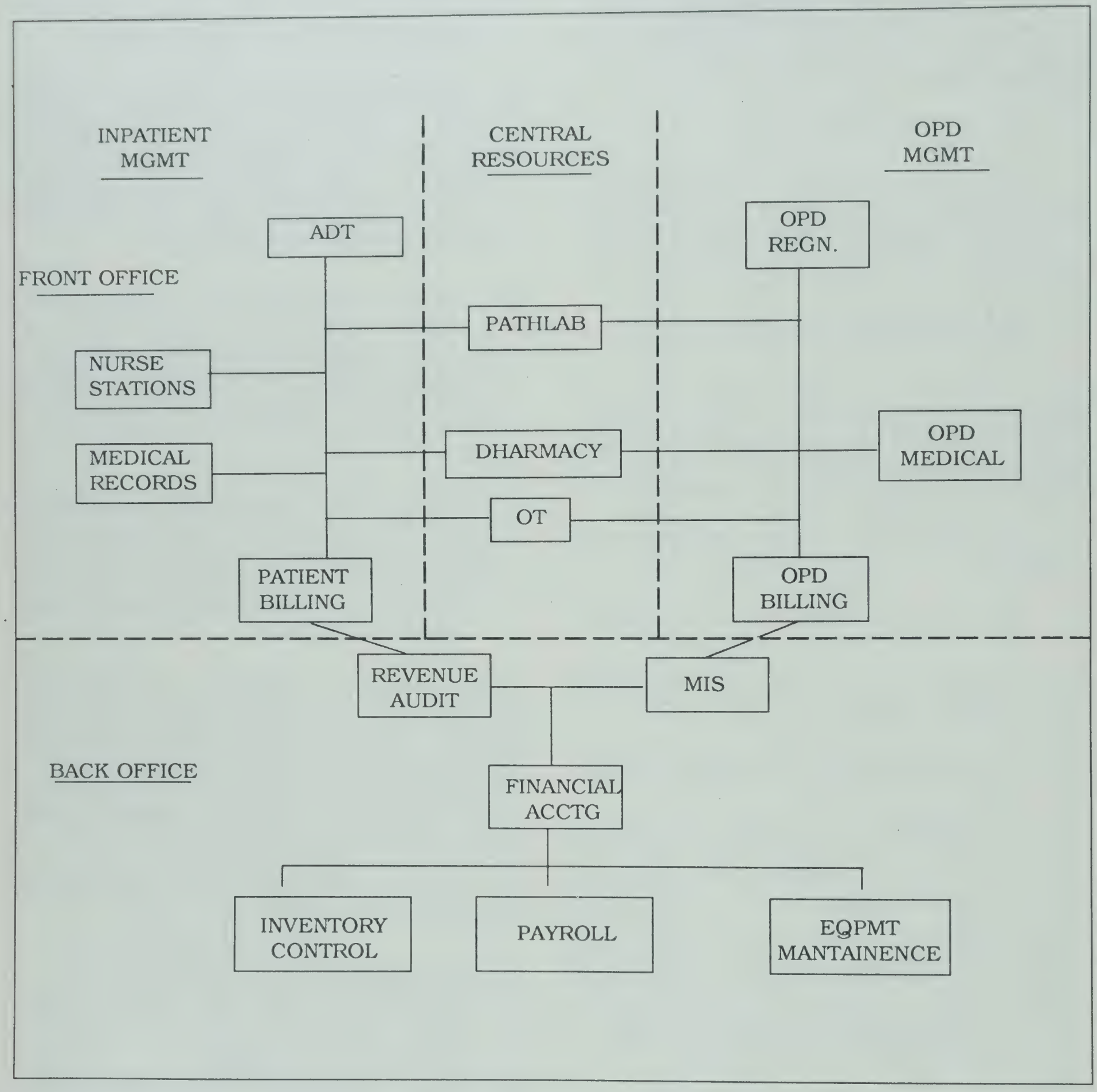
Having chosen a consultant, one should work with him to finalise upon the exact specification required. Also one should insist upon the detailed plan with committed time schedules and a comprehensive budget inclusive of all incidental costs. With clarity on the plan of action one can now place the necessary orders.

The various steps involved after the planning and procurement stage are:

1. Preparation of site for computer room.
2. Installation of hardware
3. Installation of software including customisation to meet specific needs.
4. Training of hospital staff.
5. Finalisation of various associated forms and procedures.
6. Creation of initial master data.
7. Trial Run.
8. Cutover to computerised system
9. Review and computer operations audit.

With adequate planning and meticulous execution these activities should take between 3-6 months if a good quality, proven software package is used as the starting point. One must remember that the hospital administrator's involvement and commitment to the project will be essential if the computerisation is to succeed.

FIG-I. COMPUTER AIDED HOSPITAL MANAGEMENT SYSTEM



21. Data Processing-Upgrading Hospital Communication and Organization

*W. Birkner**

It is not only for reasons of economy but also in the interests of reducing stress for staff and patients that the seperate departments of a hospital, each usually equipped with a computer system selected only with regard to its own needs, should all be more closely linked together in order to achieve more efficient communication within the hospital. This calls for technologies capable of effectively supporting the process of information and communication throughout the hospital as a basis for better planning, control and supervision. It also requires functional systems for networks, with which voice, text, graphics and images can be transmitted as well as numeric data.

Radically new approaches for information processing in health care have been developed in the course of the past decade. Developments have centered on automatic data processing. This goes beyond a logical extension of mechanization; it means the increasing integration of mental functions into automation as well.

The aim of all efforts undertaken in this direction is to construct an integrated information and communication system for routine and control functions in hospitals and other health care facilities which allows of processing action-oriented information and provides better communication through advanced technologies. These include:

- ☐ In-house communication and telecommunication services,
- ☐ Integration of information-processing and communcation systems.
- ☐ Image processing, transmission and filing on the basis of digitized pictorial information,
- ☐ Expert systems as a basis of the development of artificial intelligence.
- ☐ Communication networks.

Classified by functions,the four principal sections of hospital organization are:

- ☐ Patient services
- ☐ Medical services
- ☐ Supplies and waste management
- ☐ Administration

All of these are closely connected at the communication and information levels. (Fig-1)

A special place is occupied by the diagnostic and therapeutic services within the medical services section and by the patient services.

Tasks to be managed

Each of these sections involves different duties which must be coordinated with all others.

Medical services

The medical services of a hospital may be divided into diagnostic (laboratory, x-ray, nuclear medicine, ECG, pulmonary function testing etc.) and therapeutic (radiology, physiotherapy, surgery, anesthesia, dialysis, etc). Among these,the therapeutic and diagnostic facilities of conventional roentgenology, but particularly the modern imaging methods of computed tomography, ultrasound, magnetic resonance imaging and digital subtraction angiography are inconceivable without computerized technology. Use of computers has similarly revolutionized nuclear medicine and intensive monitoring, electrocardiography and other methods. This is readily understandable when considering that in some of these techniques millions of bits of information have to be processed every second.

Apart from many improvements to detail made on specific systems, the one development of recent years that has had a major impact on imaging quality is the digitization, manipulation and storage of images made possible by microelectronics.

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Computer technology is in other words a fundamental part of established and new imaging methods. It is at the same time a prerequisite for ensuring greater economy in the organizational environment of diagnostic and therapeutic services. In this area, electronic data processing mainly supports administrative tasks such as:

- ☐ registering requisition and work orders,
- ☐ work preparation,
- ☐ appointments and admission planning,
- ☐ scheduling,
- ☐ production of diagnostic reports,
- ☐ managing medical records and files,
- ☐ recording services rendered,
- ☐ staff planning,
- ☐ recording, processing and evaluating data produced by diagnostic tests,
- ☐ tracking therapeutic trends,
- ☐ production of statistics for scientific investigations.

Computers also afford support for the specific departments or disciplines by measuring and calculating physical function parameters in cardiology, preparing irradiation plans and determining individual dose distributions in radiology, recording and processing vital sign data in intensive medicine,and the like.

In addition to these examples in therapy and diagnosis, computer assistance is important in the organization of laboratory work as well.

Laboratory organization

The working time available in laboratories is generally split among a large number of routine jobs. The support given by a computer-aided laboratory system begins at recurrent manual tasks (paperwork), specifically preparing worklists, managing the laboratory log books, entering test results, and producing statistics for quality control and internal accounting. Depending on the type of organization and equipment, the time available for making tests—tests being the prime function of the laboratory staff after all— can be increased. The result is an improvement in both quality and quantity of output.

With an average of 15 separate test parameters per patient, approximately 60 handwritten entries or some 350 numbers, letters and marks will have to be made by hand from the time a sample is logged until the results are sent out to the requesting departments in a manually organized laboratory. These entries include preparing worklists, noting the results of the test, recording the date in the lab logbook, keeping statistics for quality control and performance tracking, and accounting.

Existing laboratory computer systems are for the most part island-site configurations, which need to be integrated into an in-house network within an overall hospital information and communication system.

Patient services

The duties with which the various patient service departments are charged, patient data management, wards, outpatient facilities, medical records—require flexible adaptation of an information and communication system to the respective organizational structure of different types and sizes of hospital. This is all the more a problem, as the medical and nursing services are one area in a hospital which normally suffers from deficient organization. The aim must therefore be to improve the information and communication structures. Digital data processing can be a valuable aid in achieving this.

Use of computers and data processing is especially desirable to solve the following problems:

- ☐ Accelerating and streamlining operating procedures.
- ☐ Reducing manual activities
- ☐ Avoiding duplication of effort.
- ☐ Relieving staff of tedious routine.
- ☐ Avoiding need for coding of information.
- ☐ Reducing and simplifying paperwork (forms).
- ☐ Speeding up the exchange of information, upgrading its currency.
- ☐ Increasing the reliability of data processing, keeping better control of the course of treatment.
- ☐ Improving time management within separate functional units and service centres.
- ☐ Producing statistics to support decision making and calculation of fees.

Basic methods already available for these purposes cover the scope outlined below.

- ☐ *Ward organization*
  Management of services provided to patients in the sense of planning and scheduling care, admissions or appointments and reappointments, recording care administered, and staff planning.

- ☐ *Requisitioning services*
  Requesting and reserving services to be

performed by diagnostic and therapeutic departments, requisitioning medical supplies, drugs, food, equipment, etc.

- *Medical subsystems*
  Collecting requisitions (e.g., for laboratory tests) and allocating them to the supply or service departments, recording services provided and results of tests/examinations, supplying results of tests of the requisitioner (e.g., wards). and administration. Preparation and supply of data for scientific and statistical evaluation, administrative decisions, project plans and control functions.

- *Scheduling*
  Issuing, booking and managing reservations and supplying information on reservations concerning both patients and the medical and technical services of the hospital.

- *Archives*
  Archiving and managing files, charts, films, scans, specimens, etc.

- *Medical records*
  Centralized information system with integrated presentation of detailed, patient-based data as a basis for monitoring service provided and effects. Random presentation of data by visual display unit relative to time or result.

Developments and trends

Reference to new information and communication techniques at the present time means the new technologies for storage, processing and transmission of all types of data.

The progress that has been made in solid-state technology has made possible much denser storage and faster processing and transmission of data, text, voice and images.

These technologies, moreover, form the foundation of a process of development enabling the techniques of communication and information processing to be linked together or integrated into complex systems.

They are leading to far-reaching changes in hospital organization, including the networking of separate computers within a hospital, which will have lasting effects on communication in hospitals of small and medium size as well.

Strong impetus is being lent to developments in this direction by the rapid growth in hardware performance accompanied by increasing miniaturization (microcomputer systems) and a drop in prices of some equipment.

One development in the offing concerns networks linking up computers of the most varied kinds, each computer being connected to a large number of visual display terminals which give the end user access to the complete network. The first steps in this direction have been taken with the introduction of voice and digital data communication systems (Fig. 2).

Voice/data system(ISDN)

At the heart of the system concept is the digital exchange, designed around an automatic telephone switchboard.

Computer systems of varying size installed in the separate departments or sections of the hospital can be connected through this exchange to the normal telephone circuit of the building. In this way it is possible to construct the information and communication system step by step, connecting up integrated data processing systems that have proven themselves in practical use for specific departments or functions, e.g. administration, laboratory, pharmacy, word processing. Additional services such as paging, public address and video transmission system can be similarly connected. Data transmission between the separate processing systems is made via automatic switching of the required line connections under software control. This enables concurrent data and voice communication between separate departments of the hospitals via the telephone circuit.

Working from a normal VDU workstation or emulation-compatible PC, it is also possible to access any computer system within the hospital via the central digital exchange and to work with programs selected from a menu in the familiar manner.

Another special feature is the possibility of connecting a voice bank system to the digital exchange, enabling oral messages to be transmitted to different receiving stations, where they are deposited in a personal mailbox.

The core of a system configuration as described above is ISDN—integrated service digital network—the magic formula for electronic upgrading of the telephone system, which means that no distinction is made between voice, text, image or electronics data bit in the transmission of information via the communication lines.

Manifold advantages result from ISDN technology. For instance, conventional analog transmission of one letter page containing 25000 characters takes up to 10 seconds; in digital transmission this is done in half a second, meaning 20 times as fast. In other words, for the same charge to send one to two pages of text over the analogue telephone link, an all digital system will transmit about 40 pages.

Whereas new ISDN-based exchanges are already in operation, successfully supporting the in-house communication network of numerous hospitals in West Germany and other countries, the general introduction of digital transmission and switching technology to the public telephone system will presumably take place more slowly.

Aside from the obvious advantages which ISDN offers to users now and in future, the decisive problem lies in the volume of information or data to be transmitted. Owing to the relatively limited transmission capacity per channel, ISDN is at the present time not suitable for fast transmission of large amounts of data, high-resolution color graphics and moving pictures. Work is however proceeding on solving this problem.

Local Area Network (LAN)

An alternative to the voice/data system centered on a digital exchange is the local area network, which is a concept for high-speed transmission of text, data, graphics and images over a single hardware link. Such an in-house information transmission system enables several stations at different locations in the same building or more widely spaced "local area' to communicate directly and to utilize common sources of information .

All data or other information important for decision-making and for control purposes is thus accessible and exchangeable throughout all relevant sections of the hospital.

The technical implementation of LANs is based on a single 75 ohm coaxial cable of the type also used for closed-circuit television, installed in every pertinent room of the hospital and used to handle data, text, graphics, voice and image communication.

By means of an appropriate intelligent interface (packet communication unit), different and otherwise incompatible computer systems, word processors, visual display terminals and printers can be linked into the network, as can wireless staff location systems, fire alarms, patient monitors, nurse call systems, surveillance and safety facilities.

Moreover, a LAN is a medium for replaying commercial radio and television programs, as well as a transmission route for the hospital's own closed-circuit video (Fig.3).

Advantages of such a network lie not only in the diversity of the hardware and services that can be connected to it but also in its flexibility, i.e. the ease with which the equipment can be connected up and disconnected at various points along the cable run.

Final note

In this article an attempt has been made to sketch major trends in development which will affect hospital organization in any restructuring aimed at more economic management and better communication. Judging from the present situation we can assume that the coming changes will be more revolutionary than evolutionary in nature.

The prospect is one demanding adaptation on the part of everyone in a position of responsibility who is concerned with the introduction or expansion of electronic data processing in hospitals.

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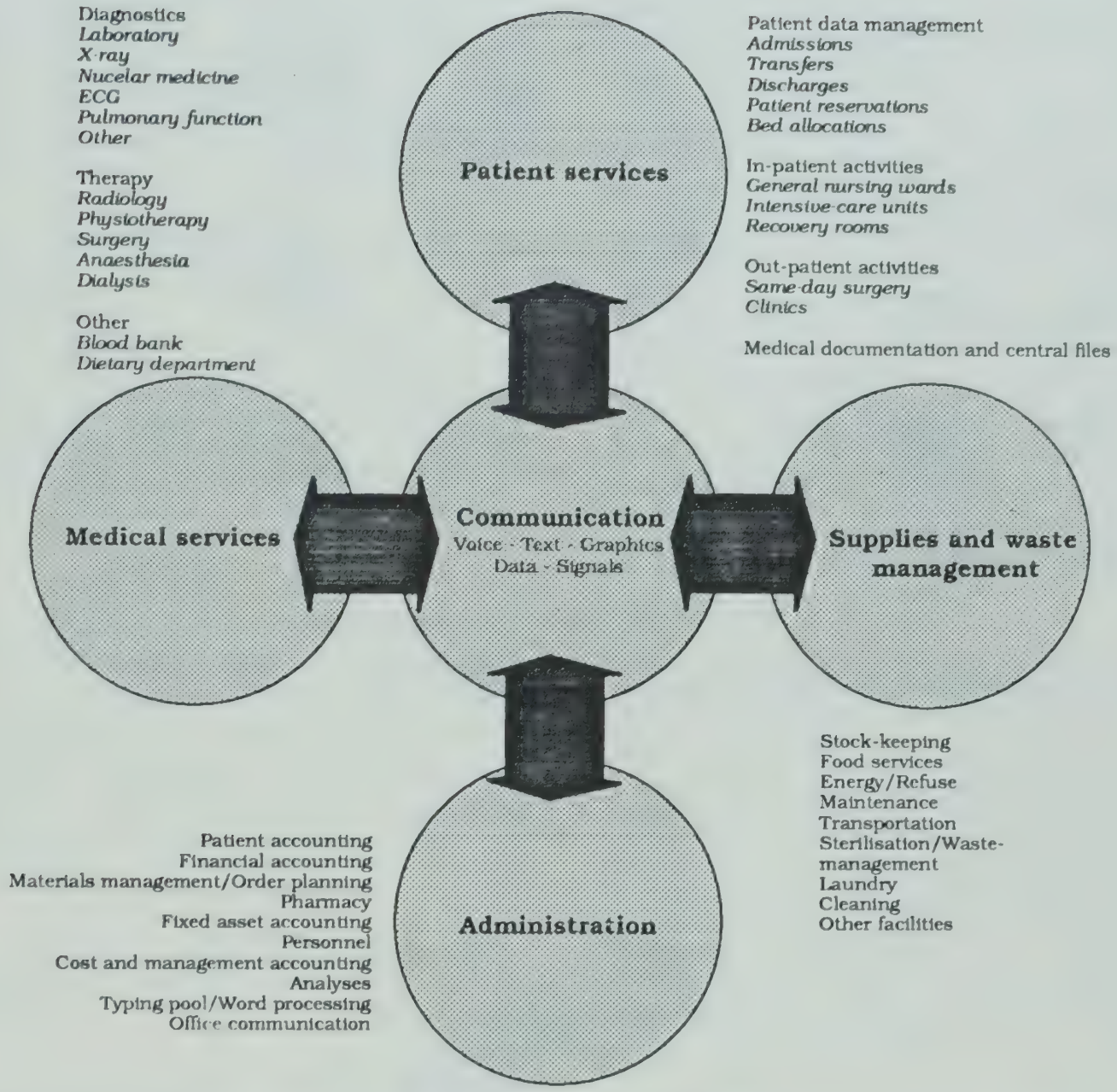

Fig 1: Integration of all sections of a hospital through communication and information systems

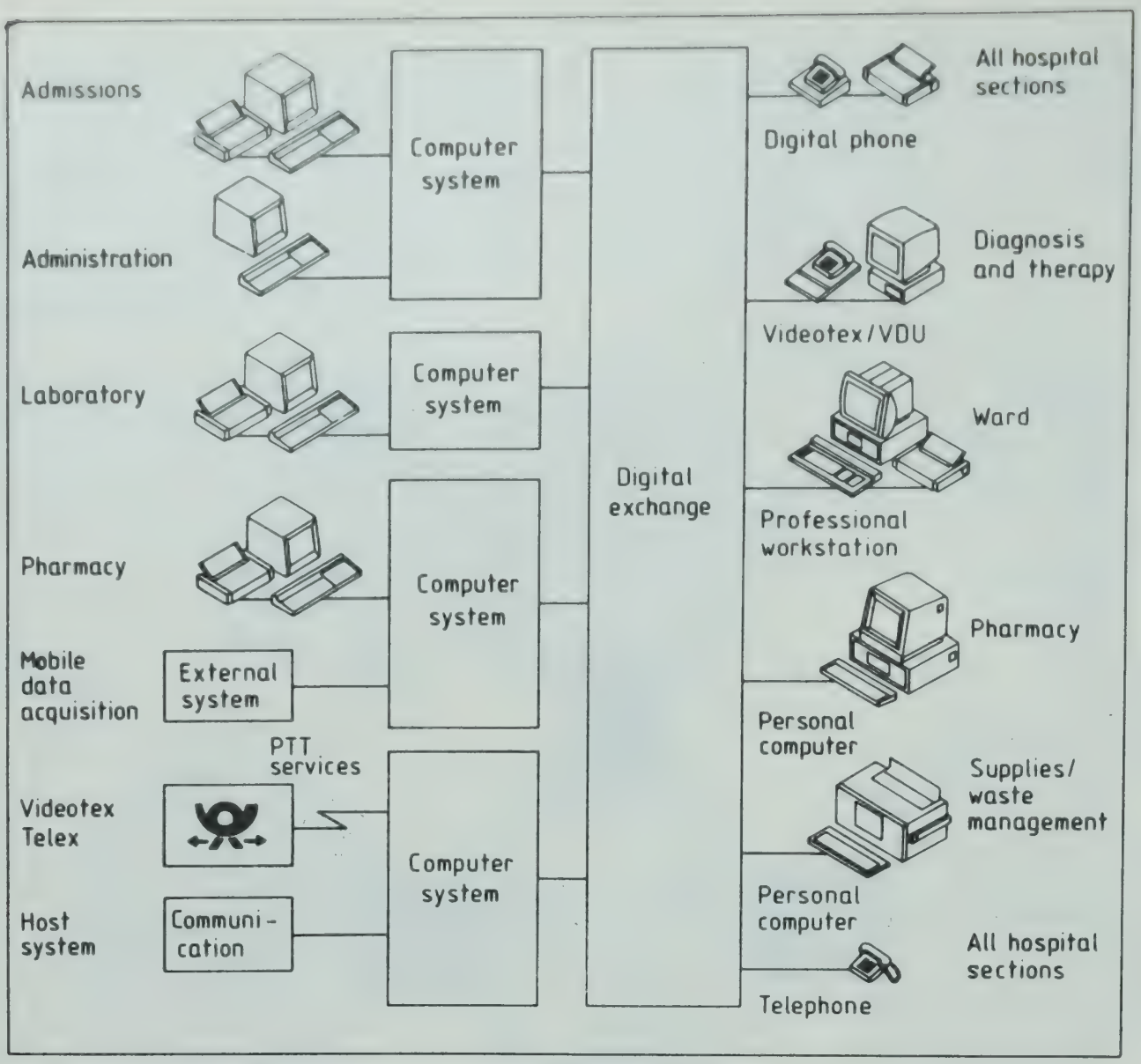

Fig. 2: Integration of hospital sections through voice/data systems

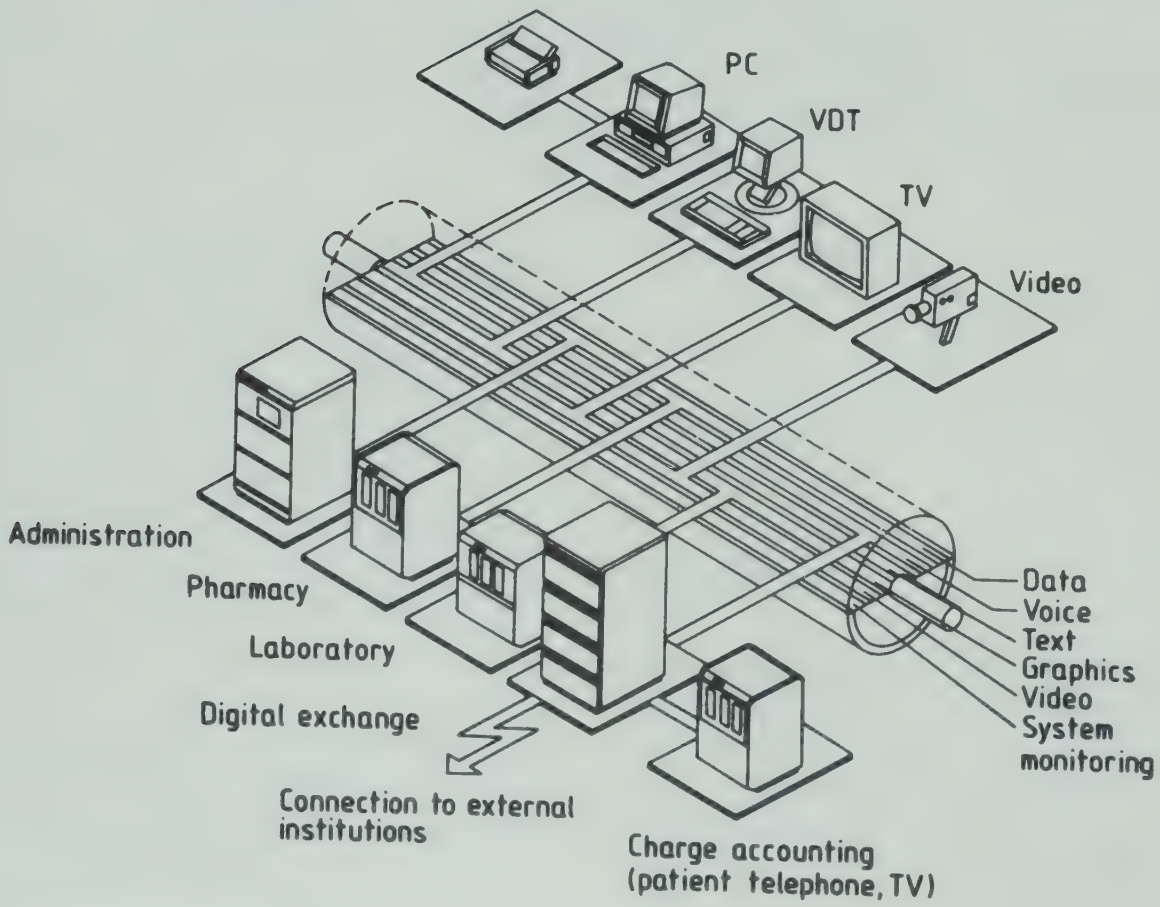

Fig. 3: Local area network for hospitals

22. Ensuring Quality of Care by Introducing Systems of Continuous Surveillance and Feedback

Dr. Kirsten Staehr Johansen M.D., D.D.S*

I. Introduction

In the "Health for All by the year 2000" document, Target 31 states that "By 1990, all Member States should have built effective mechanisms for ensuring quality of patient care within their health care systems".

Ensuring good quality of care is the most comprehensive task that health care administrators could be asked to perform. While most health care workers strive to deliver high quality patient care, and honestly believe that this is what they are providing in their daily work,only in some few cases is this honest and good intention subject to a continuous and systematic evaluation.

II Quality of Care Through Continuous Monitoring

One way of ensuring quality of care is by introducing systems of continuous systematic monitoring. Systematic monitoring and surveillance has already been employed in many different medical fields. Many countries can readily provide data on a wide variety of health related topics such as perinatal mortality, frequency of hospital acquired infections and incidences of specific communicable disease.

However, this process of data collection leads only in a vertical direction. Small units are obliged, by the health authorities, to supply data at specified time intervals to a more central agency, whether this be regional or national. Here the data is collated, processed and the results published in big summaries, e.g. the annual reports of most European Health Authorities.

Such documents estimate the total size of a problem, shows averages and ranges for a given condition. A lot of very valuable data is collected in this way, but unfortunately it is seldom used to its full extent. If such data was used with comparison of variation of outcome and cost in mind, the best performing centers could be identified. An exchange of ideas between centers and, the analysis and understanding of best demonstrated practice, could be established, with improvement in the overall quality of care as a direct result. Unfortunately this type of data is most often reserved for documenting that some minimal standard laid down by the government is being adhered to. The political system in a given country has a strong influence on the compliance of the individual centres in submitting data, and the extent to which such centrally registered data actually reflects the health situation in a country will of course vary tremendously. Data derived in this way may therefore be subject to appreciable selection.

Centralized registration in all forms shares the common problem of having a very long time lag between the time of data collection and publication of the results. Removing this time lag is one of the cardinal points when setting up systems of continuous surveillance and feedback. Therefore the surveillance/monitoring process must be carried out at the local/unit level and feedback must be continuous with minimal timelag. This will ensure that the necessary interventions can be made immediately.

The immense importance of online speedy feed back is given in the following example: "The annual report on the prevalence of perinatal infectious diseases 1986 (published autumn 1987) shows that the rate of umbilical infections in region A has more than doubled during the second quarter of that year, but had fallen to the previously registered level by the end of the year. By autumn 1987 no single person, or body of people, was interested in or had the proper conditions for investigating what had caused this rise in infections. A system of continuous surveillance with immediate feedback would have registered such a change at a point in time, where an appropriate investigation could have been carried

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out, and relevant measures taken. In this example, the oil used when bathing the newborn, (supplied by a regional pharmacy) was shown to be infected by Pseudomonas species.

This may seem a simplified example and a problem of minor importance and some may argue that such a situation would quickly be noticed by the staff. However, most patient care is being carried out by teams of staff, and single incidents are often interpreted by the individual staff member as a sporadic case, and therefore one not warranting further action. By employing a systematic and continuous monitoring system, and making this a permanent component of the routine activities, even small changes can quickly be detected.

Patient care involves the work of many different groups of health professionals, and as a result one often meets the obstacle of where responsibility should be placed. When the aim is to ensure good quality of patient care it is an absolute prerequisite that single individuals,or small teams, are made responsible for their own actions. This element of accountability is very important and must be incorporated in the monitoring system.

The simplest example of accountability is the surgeon who as an individual is responsible for the surgery he performs. This seems quite natural and straightforward and is well accepted in the case of operative procedures, but there is no reason why the same accountability should not be applied to other simpler but very common interventions such as placement of i.v. channels and urinary catheters.

The above emphasizes individual accountability, but the same concept must also be applied to small groups of staff. If, for example, having introduced a system of continuous surveillance it were to suddenly become apparent that the rate of wound infection has increased considerably at a specific operating theatre, the entire group of staff involved must be made responsible. The people actually working in the place in question are the ones best suited to investigate what changes in staff, procedure, etc. is most likely to have caused the observed change in rate of infection. The more multifacetted and multi-disciplinary the object of surveillance is, the greater the need for the system to be strictly local, and the feedback to be immediate.

Personal or group accountability has often been difficult to establish as the health care workers involved have tended to perceive such registration as a tool which would primarily be used to reinforce greater activity. Secondly, there has been fear that such systems would be used indiscriminately at times when cutbacks were being made, and as a factor in job promotion.

It is therefore important when introducing such monitoring systems to explain carefully the aim, to be precise in describing where and to whom such data will be made available, in order that the staff participating will feel secure. Ensuring job satisfaction among the health care workers at all levels is a necessity for the obtaining of optimum quality of patient care. If this is not the case, one runs the risk of staff deliberately "forgetting" the registration, and then the system is reduced to one that only gives false security. Any such continuous systematic registration only has value if all cases intended to be monitored are in fact registered.

Therefore, it is very important that such systems are not made to look complicated or mysterious,but made user-friendly and incorporated as a natural routine method of ensuring optimal patient care. In some places, great difficulty will be met when introducing this concept of continuous self-assessment, and it may be essential for overall success, to devote a lot of time and effort to promoting the necessary changes in attitude before introducing the system.

Another difficulty with ensuring quality of patient care is the problem of having to quantify "quality" at consumer/patient level, and actually measure patient satisfaction. Although patient satisfaction is a multifacetted and somewhat intangible entity, which the medical profession has not previously been forced to include in their research, this does not justify that the issue is ignored. Interview surveys, questionnaires, visual analogue scales, and may other tools have been introduced - mainly by social scientists.

Sets of indicators for patient satisfaction have now been both developed and tested, and are ready to be used in the process of obtaining good quality patient care. Patient satisfaction must naturally be measured in the local environment and the feedback used to deliver care in the way that is most in accordance with patient wishes and demands. Here it is important to realize that ensuring quality of care is a dynamic process which must change in line with social and cultural changes in the society where the care is being delivered. Although many procedures in

the Health Care System are largely obsolete and of historical origin, there may be enormous antagonism to changes regardless of the fact that there are no relevant contemporary reasons for not discarding previous procedures .

III Conclusion

If target 31 of the HFA 2000 is to be achieved, which requires that Member States build up formal mechanisms for ensuring quality of care, it will be necessary to employ and test many different solutions. This paper introduces the concept of continuous surveillance with built-in self-assessment and evaluation carried out at the local level, as one method of ensuring quality of care.

The Quality of Care and Technologies' programme, WHO/EURO is actively promoting this idea, and has both initiated studies entirely based on this concept (DANOP-DATA), and incorporated this concept into other present studies (tonsillitis and MRI studies).

How this concept is best and most practically introduced, depends on the level and type of information being monitored, and the local setting. Where computers are available and have become part of the routine, these may greatly facilitate the process, but they are not to be thought of as a prerequisite for introducing the idea. The idea of self-monitoring may be introduced equally well using manual counting, punch cards or other non-computerized methods.

Of greatest importance is the fact that the people using these methods should themselves have decided on the method and format of registration in order to get the best functioning system. If this is not adhered to, the monitoring will quickly become incomplete and consequently be worthless.

Lab Diagnosis

23. Use of the Immunoperoxidase Method as an Alternative to Immunofluorescence For Detection of Antinuclear Factor

A.T. Chablani, B.Sc., DMLT, Kalpana Deshpande, B.Sc., S.S. Badakere, M.S.c., Ph. D., M.M.Mehta, M.Sc., Ph.D., and Nafisa Contractor, M.Sc, Ph.D.

Autoimmune diseases, such as systemic lupus erythematosus (SLE), are diseases with aberrations in both cell-mediated and cellular immunity, and are characterized by the presence of one or more serum autoantibodies, which react with nuclear components and are designated as antinuclear factor (ANF). Basically, the ANF is neither tissue- nor species-specific; therefore nucleated cells from various sources can be used by the indirect immunofluorescence assay (IFA), using antihuman globulin serum tagged with fluorescein isothiocyanate, under a fluorescent microscope. The present study shows the detection of ANF by the immunoperoxidase method, which can be used in any laboratory, even one without access to a fluorescent microscope.

Material and methods

Fourteen SLE patients' sera, which were referred to our laboratory for an ANF test, were selected. The ANF was tested on a composite block containing rat liver, mouse kidney, chicken RBCs, and human leukocytes from peripheral smear by the indirect IFA using broad spectrum and monospecific antihuman globulin sera tagged with fluorescein isothiocyanate and standard methods.[1-3] The ANF was also detected by a newly developed immunoperoxidase [4,5] method for ANF, which is described as follows.

Multispot slides (flow laboratory) were coated with poly-L-lysine as described by Mehta in 1983[5] and were fixed with the nuclear material. Each spot of the nucleated, fixed slide was treated with 10 µl of ANF-positive sera, previously diluted 1:10. The slides were incubated for one-half hour at room temperature and washed 12 times with PBS pH 7.2. The slides were then treated with 10 µl rabbit anti-IgG: Anti-IgG_2 and Anti-IgG_4 were also used (anti-IgG_1 and anti-IgG_3 were tested by immunofluorescence because appropriate antisera were not available for immunoperoxidase testing). To these slides were added 10µl swine antirabbit immunoglobulin, dilution 1:30 and 10 µl of peroxidase antiperoxidase Ig complex (1:100). At each step of the treatment the slide was shaken on a Yankee Shaker for 10 seconds, incubated at 4°C for 20 minutes, and washed 12 times with PBS pH 7.2. Slides were immersed in freshly prepared Carbazol and hydrogen peroxide for 30 minutes at room temperature; they were then washed with barbitone buffer and PBS and stained with hematoxylene dye. The slides were mounted using glycerine buffer and viewed under a light microscope. Positive control was prepared by using rabbit antihuman IgG in place of subclass antisera and a negative control was prepared by using either PBS or normal human serum in place of ANF-positive sera. The peroxidase-positive reaction was read as a deep brown color.

Results and discussion

Fourteen SLE sera containing the ANF were also tested by the immunoperoxidase technique using poly-L-lysine-coated slides for better attachment. As seen from Table,1 all the sera showed good reactivity by both techniques. The samples were also rested for the IgG subclasses, where IgG_1 and IgG_3 were tested by IFT and IgG_2 and IgG_4 were tested by immunoperoxidase.

Of the 14 cases, only IgG_1 was seen in six, IgG_1 + IgG_2 were seen in two, IgG_1 + IgG_3 in three, IgG_1 + IgG_3 + IgG_4 in one, IgG_2 + IgG_4 in one, and IgG_2 + IgG3 in one case. Past workers[6] have observed

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IgG_1 and IgG_3 subclasses in patient with SLE who had nephritis, and IgG_2 and IgG_4 in patients with out nephritis. Our study analyzed on this basis shows six patients without nephritis, of which three had IgG_1 + IgG_3, one had IgG_2 + IgG_4, one had IgG_1 + IgG_2, and one had only IgG_1; whereas, in other eight cases with nephritis, all had IgG_1, two had IgG_3, two had IgG_2, and one had IgG_4. The method described here seems to be an easy alternative method for detecting ANF and can be used by any laboratory with an ordinary microscope, thus eliminating the excessive cost involved in purchasing a fluorescent microscope. The immunoperoxidase method can also be further used to characterize the immunoglobulin nature and titer of the ANF.

Table 1
Detection of antinuclear factor and IgG subclasses by Immunofluorescence and Immunoperoxidase Techniques.

	SLE patients	Immuno fluorescence ANF Test	Immuno peroxidase ANF Test	IgG subclasses			
				G1	G2	G3	G4
1	He	+	+	+	+	-	-
2	Sr	+	+	+	-	+	-
3	Za	+	+	+	-	+	-
4	Sh	+	+	+	-	-	-
5	Sn	+	+	+	+	+	-
6	Mo	+	+	+	-	+	-
7	So	+	+	+	-	-	-
8	Ja	+	+	+	-	-	-
9	Ma	+	+	+	-	-	-
10	Man	+	+	+	-	-	-
11	Sha	+	+	+	-	+	+
12	Shai	+	+	-	+	-	+
13	Ch	+	+	+	-	-	-
14	Mu	+	+	+	+	-	-
15	Normal Donor	-	-	-	-	-	-
16	"	-	-	-	-	-	-
17	"	-	-	-	-	-	-
18	"	-	-	-	-	-	-
19	"	-	-	-	-	-	-
20	"	-	-	-	-	-	-

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New Diagnostic Method for Lepros Announced

A new diagnostic method using a chemically synthesised antigen enables simple and early detection of leprosy bacteria infection in humans, even before outward signs of disease appear. This test should shortly be introduced into National Leprosy Control Programmes. The test would enable Multi-drug Therapy to be even more effective in bringing the disease under control in the patient.

According to the Director General of the WHO, Dr. Hiroshi Nakajima who was formerly regional director of WHO's Western Pacific region, "With this new diagnostic method and multi-drug therapy, together with recent progress in development of vaccines, the eradication of leprosy is no longer a distant dream".

Ref: medical focus, 4/1987, pp5

Unnecessary Laboratory Testing

It was found that patients with several physicians undergo more unnecessary laboratory tests than patients with a single physician. 198 patients who were admitted to a teaching hospital and were referred to several physicians showed remarkable duplication of testing procedures ordered, that too on the same day. Of the 936 automated chemistry profiles ordered during the hospital stay of these patients, 254 were unnecessary duplicates, being the second or even third specimens processed on the same day, and on the same patient. Duplication increased with the number of physicians ordering tests.

This finding could be an indication for computerising laboratory data, so as to provide automatic data on tests already performed, in case the tests are requested by a second or third physician. Especially in teaching hospitals where shortage of paramedical manpower is experienced, computerisation of laboratory data and if possible, linking it with out-patient and in-patient computerised data could save much money and personnel time by avoiding duplication of effort.

Ref: Labmedica Vol V, No 4 8-9/1988 pp16

24. Reagent Strips-New Perspectives for Diagnostic Tests

*B. Muller, S. Kaupp**

Reagent strips connote the means to perform diagnostic analytical tests on the spot in the medical office with a minimum of instrumentation. They are characterized by both speed and optimum availability. Speed in this instance means that the answers are obtained within no more than five minutes of collecting the specimen, while availability means that the test can be made very easily and at any time of the day during which patients are received.

Today's medical offices have at their disposal a wide assortment of "dry chemistry" reagent strips for urinalysis which have introduced considerable simplification and added safety to routine clinical laboratory work. As an example, one screening test strip contains reagent areas to detect the kidney-relevant parameters protein, erythrocytes, leukocytes, pH and nitrite, thus furnishing diagnostic information on processes in the kidney and urinary tract. If a positive result is obtained for any one of these parameters, further tests on a centrifuged urine sediment are indicated, as has been demonstrated by extensive studies with several thousand urine specimens.

Reliable results of analysis with reagent strips are, however, dependent on specific test reactions. This means, for example, that ascorbic acid or other interfering substances must not disturb the determination when testing for glucose and blood in urine.

This review contains examples of the various possibilities of using reagent strips in the medical office available at the present time or due to become available.

Testing for diabetes

Like those for urinalysis, reagent strips for determination of blood glucose levels have been repeatedly improved in recent years and have similarly come to be standard aids for diagnostic tests conducted in the medical office.

What is required most in visual matching semiquantitative glucose test strips is a broad span of measurement and good differentiation of color change. Both requirements are answered by reagent strips which cover a blood glucose range from 20 to 800 mg/dl.

A decisive breakthrough has been achieved in the quantitative determination of glucose in blood by a combination of computer-readable bar code and microprocessor-controlled detector, which assures very simple yet extremely accurate measurement. Within about minutes it delivers a digital reading of the exact blood glucose concentration, thus enabling the physician to institute immediate therapeutic action where necessary.

Proceeding from the experience acquired in diagnosis of diabetes, an instrument has been designed which measures other parameters in the same simple manner This reagent strip system is capable of directly analyzing enzymes and substrates in capillary or venous blood specimens. Its design and uses are described in the following.

Test system

The system comprises a reflection photometer fitted with an Ulbricht sphere as the key component of the optical two detection train and the appropriate reagent strips. Specific reagent strips are used for the various enzyme and substrate tests (Fig. 1). Construction of each has three distinctive features:

- ☐ The magnetic code contains all the information necessary for carrying out the test and calibrating the photometer for the specific analysis.
- ☐ The plasma separation area consists of different layers of glass fibre and paper, in which the corpuscular constituents of the blood are separated. This area is a substi-

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tute for the centrifuge in the laboratory.

- The reagent area is similarly made up of different paper layers impregnated with the reagents required to produce the respective reaction. Blood plasma diffuses from the plasma separation area into the reaction area, where it causes a color change which is measured reflectometrically.

Test procedure

Approximately 30 µl blood, serum or plasma is applied by pipette to the reagent strip, which is then inserted in the instrument. The instrument reads and processes the information stored in the magnetic code and, after about three minutes, the result of measurement is displayed as a digital reading. In other words, the test involves just three simple steps:

- Pipetting the specimen
- Inserting the reagent strip
- Reading the result

Even when making different tests, no adjustments are needed on the instrument itself, as all the specific information for the new test is likewise entered via the magnetic code on the reagent strip

Comparison of methods

Results obtained with the system described are corroborated very well by those of reference tests carried out on human sera by standard "wet chemistry" methods(Fig.2). Accordingly, normal values are identical for the reagent strip test and the corresponding standard laboratory test. Every test in reagent strip form itself undergoes testing for the effects of hemolysis, biliribin, lipemia and drugs. The results are published.

Functional diagnosis and quality control

For the most part, the instrument is self-diagnosing. Any defect occurring is localized by the internal circuitry and identified on the display, helping to get it remedied quickly and avoiding erroneous measurements.

In addition, separate test strips are supplied to enable the user to make a convenient in-house check on working of the optical system. Control sera can be employed to check quality of performance. They have reference values specially determined for the instrument.

The speed with which the system works enables answers to be ready while the patient is still in the doctor's office. From the patient's past history, clinical findings and the test results the doctor can very often complete his diagnosis and prescribe appropriate treatment immediately. Beyond that, the system provides a means of differential diagnosis.

It is capable of running about 20 to 30 tests in an hour, which makes it particularly suitable for use when individual tests or brief series of tests need to be performed at intervals throughout the medical office's working day.

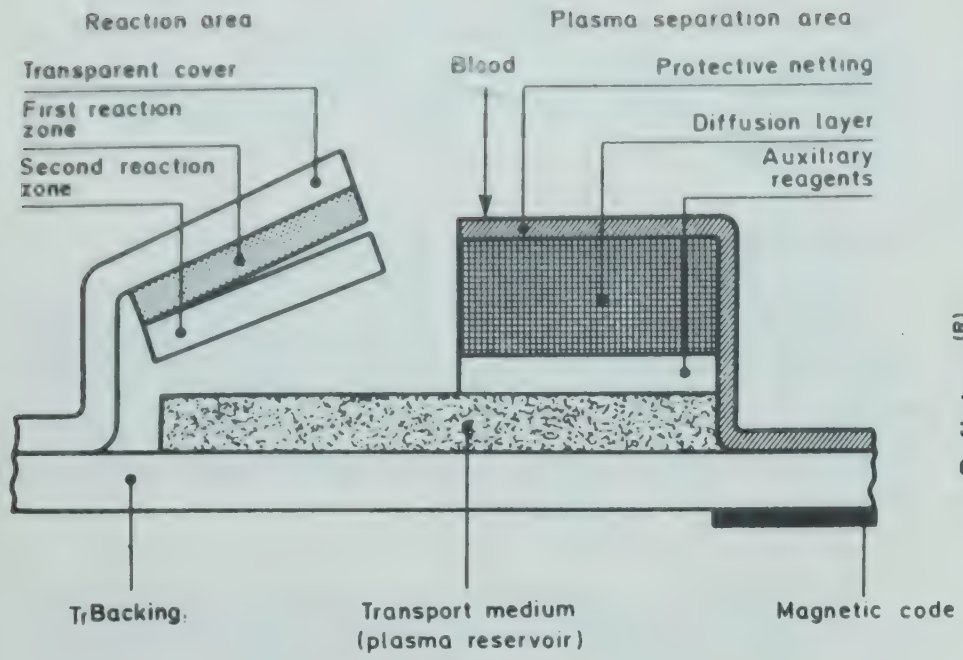

Fig. 1 Schematic construction of reagent strip

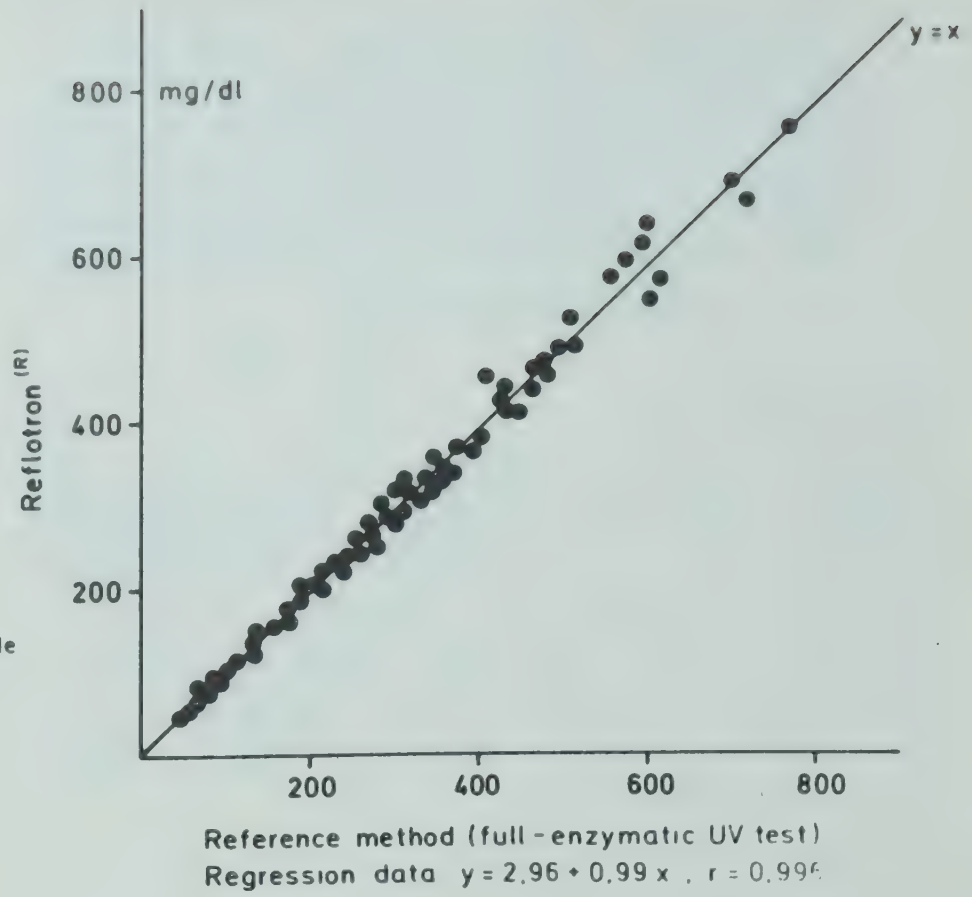

Fig. 2 Comparison between reagent strip and reference tests for determination of triglycerides

Current Perspectives in Amoebiasis

Amoebiasis is ubiquitous in distribution and perhaps second only to malaria as a leading parasitic cause of death in India and several other developing countries. While intestinal amoebiasis does not pose much of a diagnostic problem, hepatic and other extra-intestinal amoebiasis being mimicked by several other diseases (which are also common in the tropics), pose a problem for diagnosis.

In this context, immunodiagnosis, especially with monoclonal antibodies has taken a major leap forward with the development of highly sensitive and specific tests. At the Mount Sinai Hospital, New York, the Indirect Haemagglutination Assay(IHA) gave a positivity rate of 86% among sufferers of intestinal amoebiasis and 95% among patients of extraintestinal amoebiasis. The Indirect Fluorescent antibody test (IFA) gave positivity rate of 75% and 90% respectively: Direct Fluorescent Antibody (DFA) gave 100% positivity rate in both categories of patients.

The ELISA test employing monoclonal antibodies offers a sensitivity of 82% as compared with a sensitivity of 30% when we employ direct microscopy of stool, as the tool of diagnosis. ELISA offers a rapid, simple and cost- effective means of diagnosing invasive disease, and further, it can be applied to directly detect amoebic antigen in stool specimens. However all assays are limited by parameters of sensitivity and specificity of the tools, prevalence of overt, subclinical and asymptomatic infection in the community, and the skill of the technician performing the test.

Ref: Maria P. Reitano et al Labmedica, (1987) Vol IV, No.5 pp 31-34

Control of Hospital Infections

25. *WHO Programme for the Control of Hospital Infections*

Dr. Kirsten Staehr Johansen, M.D., D.D.S,*

Hospital-acquired infections (HAI) are widely recognized as a major public health problem in industrialized and developing countries and has received great attention from several international organizations including the Council of Europe, the European Community, and the World Health Organization, during the last two decades. Over the past few years, prevalence studies are considered as an instrument of choice for obtaining a general guidance to the infection rates at national levels.

Data describing the extent of HAI are available from several countries. Studies carried out in Belgium, the United Kingdom, Norway and Italy found the prevalance of HAI to be 13.3.%, 9.2%, 9.0% and 6.8% respectively.[1] In hospitals in which cost data were available, it has been possible to calculate the added financial impact of nosocomial infections due to the additional days of hospitalization, increased use of drugs, especially antibiotics, use of isolation techniques, additional laboratory and other diagnostic studies, etc. In the United States for example, in today's dollars, the cost of extended hospitalization attributable to nosocomial infections probably exceeds four billion US dollars.[2] But the human cost has not yet been taken into account.

Although numerous studies have been made in individual hospitals of the incidence and epidemiologys of particular types of hospital infections and different actions taken, no significant reduction in hospital infections at a national level has been attained so far.

Convinced of the health hazards related to HAI , the World Health Organization felt it necessary to support hospital infection control activities throughout the world. In the initial stage, WHO approaches were based on the preparation of educational material[3,4] organization of meetings, seminars and training courses, development of a network of collaborating centres, support to international societies and committees, including collaboration with the EEC and the Council of Europe.

In order to determine the extent of the problem of nosocomial infections throughout the world, a WHO cooperative study on Hospital Infection Prevalence Survey was carrried out in 1983-85 in 55 hospitals in 14 countries representing four regions (Europe, Eastern Mediterranean, South-East Asian and Western Pacific).

The records of 31,646 patients were examined and after the data were checked, 47 hospitals with 28,861 patient files were retained for the survey. The 28,861 patients consisted of 49.2% males (14,195) and 50.8% females (14,666).

The results of the prevalence survey showed that the mean prevalence rate was about 8.7% (median value - 8.4%) with a range of 3.0% to 20.7 %. However, since some patients contract at least two infections,the hospital infection rate may be estimated at 9.9%. According to this survey, approximately one patient out of ten will become infected while in hospital.[1]

A really interesting fact however was not only the mean percentage for each of the four Regions, but the range that existed. It can be noted that for each Region there are very good centres and centre where the prevalence of Hospital Acquired Infection is as high as 20%. The type of infection varied considerably according to the geographic area, i.e. urinary tract infections are most frequent in hospitals in Europe and South-East Asia (30.9% and 25.5.% respectively) whereas a high frequency of nosocomial gastroenteritis could be noted in the Eastern Mediterranean Region (17.9% of all infections). This study and numerous other studies have given valid data on the incidence and epidemiology of various types of hospital infections.

It is of interest to note that further national studies and surveillance schemes have highlighted additional findings:

In the US Senic Project[5], it was found that

* *Chief, WHO programme for Appropriate Health Care Technology;0828s 5/10/87*

in spite of the great increase in surveillance and control activities in 1983 as compared to 1976, the percentage of infections being prevented nation wide increased from 6% to 9% with no decrease in wound infection, wheres 32% could be prevented if all hospitals adopted the most effective programme. The limited decrease in the rate still justifies the cost of the programme.

- In another US study by Cruse[6], the overall rate of surgical wound infection was 4.7% but the rate in clean wounds was only 1.5% and this latter rate appeared to be a more useful indicator of control of infection.

- In a Swedish study by Kjellgreen et al[7] it was shown that a continuing registration of surgical wound infections and feedback to surgeons led to a 30% decrease.

- The Caribbean Epidemiology Centre (CAREC) has since 1985 started a project[8] which included prevalence, cost studies, reporting and monitoring, organizational models, comparison among participating hospitals, development of work sheets and guidelines, feedback and training programmes. All these various activities have contributed to a general awareness and reduction of infection, justifying the cost of the programme.

- In Italy, where prevalence surveys are now regularly carried out in hospitals all over the country, the results had stimulated a great general interest. A national programme is now in operation with a goal to reduce the hospital acquired infection rate by 20% in five years, coordinated by the WHO Collaborating Centre on hospital infection control at the Instituto Superiore di Sanita in Rome. Two special schools to train health care personnel in infection control are now operating in Italy.[9]

- In Kuwait, where there had been unacceptably high rates of nosocomial infections, a very active infection control programme was recently introduced. In view of the limited number of hospitals and district clinics, it was possible to introduce a daily surveillance scheme and the overall infection rate has been reduced from 6.0% in 1980 to 3.1% in 1986.[10]

- Finally, in a Spanish serial and cumulative prevalence study,[11] the incorrect use of antibiotics was particularly noted in surgical departments and specific measures for a more appropriate utilization of antibiotics were introduced.

The role of WHO in hospital infection control is no longer a venture restricted to a single unit at HQ; also the European Regional Office has taken up work in this field. In addition, the Appropriate Technology for Health programme has carried out an international study on the occurrence of multiresistant bacteria and national aminoglycoside consumption patterns, which has recently been completed.[12] Twelve countries participated and the study is a retrospective collection of data on resistance rates, national consumption data. Resistance rate for three specific bacterial strains: staphylococcus aureus, P. aeruginosa and E. coli were investigated. The data show an enormous variation in the resistance rates and the consequent occurrence of epidemics. This varied from 0 to about 40% when comparing two European countries. A similar pattern of enormous variations was seen when comparing the national consumption of aminoglycosides. This varied from 0.039 to 0.189 DDD/1000 inhabitants. Aminoglycoside consumption is also evaluated with respect to hospital and non-hospital utilization. In this study the relationship between the development of resistance and the consumption of aminoglycosides is clearly demonstrated. On this basis action must be taken. It is the policy of the ATH programme to actively participate in the development of guidelines for the appropriate utilization of not only aminoglycosides but antibiotics as a whole. Guidelines as such are urgently needed if the problems of multiresistant bacterial strains and occurrence of epidemics are not to become an even greater problem than already encountered today.

An ATH workshop entitled The Use and Misuse of Antibiotics will be held in Freiburg with participants from both developing and developed countries, the goal being the preparation of guidelines on the rational utilization of antibiotics, in particular aminoglycosides.

A most recent initiative of ATH is the organization of a Workshop on Hospital and Health Care Hygiene to take place in Copenhagen. It is the aim of the workshop that a Beginner's Kit in Infection Control to include appropriate use of anti-

biotics and antiseptics, can be drawn up so that Member States who do not yet have national programmes on Basic Hospital and Health Care Hygiene will have a starting point for activities in this field.

However, in order to take action in this field, it is necessary to change the attitude of health personnel at all levels, because the best guidelines or manuals will have no effect if the people concerned are not motivated to promote new ideas in Hospital Infection Control.

A crucial development which has been reported to be effective at some individual hospital levels is the stimulation of the motivation of surgeons through actually providing feedback of their infection rates[6,7]. This will now be tested in a wider context and a software has been developed to this effect (the Danop Data System). A pilot study with 15 participating countries will start during the coming year and expects the results to be compared at the Appropriate Technology for Health Workshop in 1988.

Recently, some tasks previously performed by hospital staff have been contracted out; for example: maintenance, catering, cleaning and laundry. Such areas are closely linked to hospital infection, so it is important that the "alien" staff performing tasks inside the hospital, are also taken into consideration and properly trained. Increasingly complex equipment similarly requires external maintenance engineers, who may create problems besides being exposed to potential risks themselves. But this entire question needs to be studied.

Conclusions

Appropriately conducted national prevalence studies with follow up are an efficient and economic technology when initiating infection control programmes. Furthermore, feedback and monitoring systems and a concerted action among clinicians, surgeons, nurses, other health personnel and the administration is a prerequisite for the successful implementation of these programmes.

As adequate management in the control of hospital infections is of concern to all Member States, WHO will make all efforts to strengthen joint action with national and international organizations as well as within WHO units and its Regional Offices. The objectives of WHO activities in the fields of control and prevention of hospital infections are:

- to encourage countries, hospitals, departments, and physicians to quantify nosocomial infections;
- to encourage countries, physicians and microbiologists to quantify the occurrence of multiresistant bacteria and antibiotic consumption;
- to promote international and national collaboration in identifying the most efficient and economic means of controlling and preventing these problems.

Finally, I would like compliment the Italian National Infection Control Programme for its new project :PRINOS" with its courageous goal of a 20% reduction of hospital infection by 1992 in a representative group of hospitals. It is to my knowledge the first time that such a programme has been initiated and I would like to state that this programme is in line with the Health for All Strategy where the 32 Member States of Europe have committed themselves to established health outcome goals to be achieved before the year 2000.

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26. AIDS-Prophylactic Hygiene

*Rudolf Marz**

Since the middle of the 1970s a new disease has been spreading throughout the world: AIDS, acquired immune deficiency syndrome. At the present state of knowledge, the causative agent is a virus belonging to the retrovirus family of RNS viruses which was designated "human T-cell leukemia virus Type III", HTLV III for short, by virologist Robert Gallo, director of the Tumor Cell Biology Department at the U.S. National Cancer Institute in Washington. In France, a second group of researchers arrived at similar results and gave the pathogen the name "lymphadenopathy associated virus", or LAV I.

In the known risk groups, AIDS is spreading incessantly. To date, no therapy has become available for the disease. Among those at risk are health workers who are exposed to infection via invasion of superficial wounds by body fluids of infected persons.

Correct and consistent implementation of appropriate hygiene measures is an essential part of AIDS prophylaxis in the health care professions. Disinfection of hands, skin and instruments figures prominently among these measures and enforcement of a hygiene plan in health care facilities, constitutes meaningful supportive action.

At the present state of knowledge, potential carriers of the virus may be identified among:

- ☐ Promiscuous homosexual and bisexual males
- ☐ Prostitutes
- ☐ Drug addicts
- ☐ Hemophiliacs
- ☐ Sexual partners of infected and diseased persons
- ☐ Babies of infected mothers

Much has been reported already on the disease AIDS, its etiologic agent and epidemiology, both in a scientific context and at an emotionally exaggerated level. The table presents a factual summary of the disease reflecting current knowledge.

AIDS— a summary

- ☐ AIDS is caused by the HTLV III/LAV virus, a member of the retrovirus family of RNA viruses.
- ☐ The virus is labile and is transmitted only through body fluids.
- ☐ The HTLV III/LAV virus destroys the helper T cells in human blood. This leads to a breakdown of the body's immune system.
- ☐ The pathological symptoms occurring in AIDS are multisystemic, depending on the particular pathogenic organisms that break through the immune barrier.
- ☐ Kaposi's sarcoma, a form of skin cancer,is frequently observed.
- ☐ To date there is neither a vaccine nor any treatment for HTLV III/LAV virus infection.
- ☐ The HTLV III/LAV virus can be detected very early in the blood by antibody reaction (2 to 12 weeks after infection).
- ☐ 30 to 40% of those infected contract the mild of preliminary form of AIDS, lymphadenopathy syndrome (LAS).
- ☐ 5 to 20% contract AIDS, the incubation period for which is 5 months to 5 years.
- ☐ It is suspected that additional factors burdening the immune system (e.g., hepatitis, herpes) are necessary to provoke the outbreak of AIDS.

AIDS in the health care setting

More recently, the general press has also devoted considerable space to the problem of AIDS, necessarily leading to insecurity arising outside the group of persons immediately at risk. Fear of AIDS has risen especially among people employed in health care professions, namely doctors, dentists, nurses and laboratory personnel. The fact is that every health professional is prospectively subject to contact with AIDS patients

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* *Rudolf Marz, Bode Chemie, Hamburg, West Germany.*

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and thus with carriers of the HTLV III/LAV virus.

As matters now stand, carriers of the HTLV III virus are not to be considered contagious in routine social intercourse, as the virus is not transmitted by droplet infection and normal, non-sexual physical contact. The HTLV III/LAV virus is viable only in body fluids such as blood, sperm, serum, saliva, tears, etc. and is transmitted from one person to another via these fluids (Fig. 1).

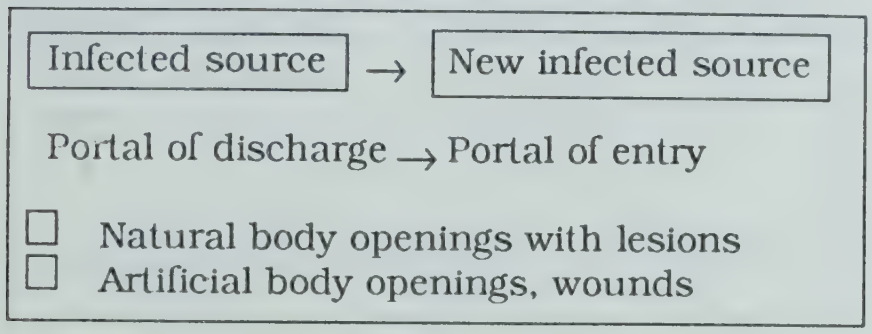
Infected source
New infected source
Portal of discharge → Portal of entry
Natural body openings with lesions
Artificial body openings, wounds

Fig 1

To date, no definitive proof has been supplied for the existence of a chain of cross-infection for the AIDS virus in hospitals. No occurrence of work place associated HTLV III infection has been reported in West Germany, not even among physicians and nurses concerned with the direct treatment and care of AIDS patients. In the USA, however, several infections, have occurred among hospital personnel.

Accordingly, transmission of the disease to staff employed in health care facilities is not to be ruled out altogether, since skin injuries as minor as an insect bite or a tiny scratch create a portal of entry for the HTLV III virus when contact is made with infected body fluids.

This makes it essential to adopt prophylactic hygiene measures for the protection of health care personnel and also of other patients.

AIDS prophylaxis

Classified as a lipophile retrovirus, the AIDS virus is most readily comparable with the hepatitis-B virus (HBV). As with HBV, aerogenic transmission does not take place but blood and secretions must be considered infectious.

In contact with AIDS-infected patients and when handling potentially infectious materials, therefore, the same hygienic precautions should be exercised as with hepatitis-B. Specifically, these are:

- ☐ Prevention of cutaneous contact with blood and other secretions
- ☐ Wearing of protective gloves
- ☐ Wearing of protective gowns and where necessary of protective goggles and face masks
- ☐ Correct disposal of used needles and scalpels.
- ☐ Use of disposables
- ☐ Careful disinfection of hands,skin and contaminated instruments

AIDS and disinfection

Like all retroviruses,the HTLV III/LAV virus may be considered labile. Outside the host organism, it quickly loses its activity. Due to its sensitivity, the virus is very quickly destroyed by virucidal disinfectants outside the body. Investigations (1) have shown 25% ethylalcohol, 1% glutaraldehyde and 0.2% sodium hypochlorite to be adequate for disinfection of instruments and contaminated surfaces.

These findings have led to the knowledge that preparations containing alcohol or aldehyde and aldehyde derivatives are well suited for disinfections in AIDS prophylaxis.

When selecting disinfectants for these purposes, only those should be considered that have demonstrated their effectiveness against the HTLV III/LAV virus in independently confirmed tests.

Disinfection of hands

In all problems associated with hygiene in the hospital,disinfection of the hands is the most important step for prevention of infection and this applies with AIDS too. Hands should be disinfected following every cutaneous contact with AIDS patients and contaminated instruments. The safest, simplest method and that gentlest to the skin is alcoholic rubs.

They enable hands to be disinfected hygienically at any time, independent from washbasin and water faucet [2] . For example, a suitable disinfectant for HTLV III/LAV prophylaxis contains 45 g 2-propanol, 30 g 1-propanol and 0.2 g mecetronium ethylsulfate (INN*), application 3 ml for 1 minute confirmed by expert test.

Disinfection of instruments

Used instruments must in principle be considered contaminated, therefore the rule to follow for the safety of personnel is:

- ☐ First disinfect, then clean, and finally sterilize or make final disinfection.

Summary of precautions

Test specimens	Should be dispatched only in sealed, water tight containers.
Gloves	Should be worn by all personnel who come into contact with blood, blood constituents, tissue, body fluids or excretions and potentially contaminated surfaces of possible AIDS patients.
Hands	Should be disinfected before and after contact with patients.
Gowns	Must be worn when there is possible risk of contact with secretions, excretions or blood of AIDS patients.
Facemasks	Normally not necessary for patients,but coughing patients should wear a mask when leaving their room in the ward (risk of aerogenic transmission of Pneumocystis carinii infection). Visitors and nursing staff should wear masks in presence of AIDS patients.
Goggles	Some form of eye protection should be worn when spattering of blood, bloody secretions or body fluids is to be anticipated. This applies especially for dentists and for physicians, surgeons and nurses in bronchoscopy, endoscopy and ENT surgery, possibly also in resuscitation measures.
Surfaces	Surfaces and furnishings which become contaminated with blood or other body fluids should be treated immediately with disinfectant.
Syringes and needles	Should be discarded into a firm sharps container. Use of disposables is preferable. Note: Personnel sustaining injury by needles should be treated by the staff physician in the normal manner. When making immune status and follow-up checks at intervals consideration must be given to the possibility of false findings due to other diseases.
Resuscitation	Disposables for mouth-to-mouth resuscitation should be available at every patient's bedside.
Instruments	Optical instruments should be treated with ethylene oxide or glutraldehyde after every use. Breathing tubes must be cleaned carefully and disinfected after use by every patient. All instruments coming into contact with blood, secretions, excretions or body tissue must be sterilized prior to re-use, including for example laryngoscopes and endotrachial tubes.
Disposables	Contaminated disposables must be disposed in accordance with procedures for infectious wastes. Bedclothes Should be transported to laundry in containers for infectious linens.
Accommodation	Generally it is not necessary to place AIDS patients in single rooms, except for coughing patients suspected of Pneumocystis carinii infection. Patients with a disordered immune system or possible communicable diseases which might be dangerous for AIDS patients should not share rooms with AIDS patients.
Staff	There is no scientific reason for medical and non-medical personnel not to attend AIDS patients. Only pregnant women should be excluded from direct contact with AIDS patients,as possible infection with cytomegalovirus could lead to congenital damage. Personnel suffering from AIDS but asymptomatic should be employed on duties which do not entail contact with patients. This is to protect such employees from opportunistic infecion and to protect seriously ill patients with a compromised immune system from infections which might be transmitted by personnel.

☐ The appropriate action with endoscopes is:
☐ Clean, disinfect, rinse with water.

A concentrated disinfectant based on glutaraldehyde and depot aldehyde with the addition of

cleaning and corrosion inhibiting agents ** is especially suitable for HTLV III/LAV prophylaxis. The recommended application, as confirmed by expert tests, is 10% concentration for 15 minutes.

Hygiene plan

When tending AIDS patients, a hygiene plan will be found to be a practical aid. The measures outlined below may be taken as an example for the contents of such a plan.

- ☐ A helpful basis for precautions is contained in the Infection Control Guideline for AIDS Patients drawn up by a work group at the University of California in San Fransisco, U.S.A. [3].
- ☐ Practical, economical and reliable disinfectants possessing proven effectiveness against HTLV III/LAV virus.
- ☐ Disinfection procedures for AIDS, specifying what is to be disinfected, when, with what and by whom.
- ☐ Regular instruction of personnel in all questions of hygiene and disinfection.

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27. Disinfection

Mattress disinfection breaks chain of infection in hospitals

*K. Bartholmess**

The purpose of disinfecting mattresses is to kill or irreversibly inactivate pathogenic microorganisms on and in the material of the mattress. To this end, mattress disinfection serves to break the chain of infection in hospitals. It is implemented with various methods and agents.

When it comes to irreversibly inactivating or destroying microbes inside mattresses, there is practically a single method which does the job to best effect, namely exposure to heat. Employed at an active temperature of 105°C and for an exposure time of 5 minutes, thermal disinfection moreover ensures effectiveness over a wide range of categories and thus achieves maximum possible disinfecting performance.

Thermal disinfection applied by the vacuum-steam method has the added advantage of leaving the mattress in well-dried condition at the end of the procedure. Before being disinfected by thermal methods, the mattresses must be removed from their protective covers.

Disinfection to irreversibly inactivate or kill pathogenic microorganisms on the outside of mattresses is usually performed with chemical agents. Among these, agents formulated with a certain content of alcohol or phenol cover only a limited category of disinfection and phenols are unsuitable for disinfection of mattresses made of polyether foam. Other chemical agents whose active substance is based on chlorine, formaldehyde, etc, are effective over a wider range and may also be used on polyether foam mattresses.

By contrast with thermal methods, chemical disinfection is performed with the mattress cove left in place. Furthermore it can be carried out on the beds in the wards, whereas thermal disinfection requires the mattresses to be transported from the wards to a separate station where the necessary equipment is installed.

The various categories of antimicrobial activity for disinfectants or disinfection methods are:

- ☐ Destruction of vegetative bacterial microorganisms including mycobacteria and of fungi including fungal spores
- ☐ Inactivation of viruses
- ☐ Destruction of spores of the anthrax bacillus
- ☐ Destruction of spores of the gas gangrene and tetanus bacilli (sterilization methods are necessary to kill these spores. e.g., pressurized saturated steam at 120°C with an exposure time of 20 minutes)

When employing disinfectants and disinfection methods, it is essential to ascertain their compatibility with the items to be disinfected.

Material and disinfection

The serviceability of a mattress is measured, among other things, by the bulk density of its material, which is a key to its durability and thus to how it will perform in extensive, heavy use. This allow of making a cautious estimate of the useful life of the mattress, a higher bulk density of the material generally indicating a longer life expectancy. There is however, no exact numerical data available on the relationship between the material's density and the anticipated useful life of a mattress.

Since the density has a strong bearing on manufacturing cost, however, the conditions under which mattresses are to be used should be examined precisely before purchasing them in order to achieve the greatest possible economy, that is the optimum ratio of serviceability and price.

A certain minimum bulk density of, say 37 kg/m^3, may be specified for example to ensure

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construction of polyethylene foam, a material capable of fulfilling the requirements on quality of hospital mattresses.

When mattresses are soiled, the detachable covers are washed separately. The polyethylene foam body itself must be cleaned either entirely or in the soiled parts with a neutral laundry detergent. Strong oxidants cause damage to the material. Organic solvents only result in swelling of the material. After the solvent has evaporated, the foam resumes its original properties, but the mattress must not be used while still in the swollen state.

The mattress lends itself to disinfection by either physical methods, chemical methods (e.g. formalin solution) or combinations of the two and thus answers one of the first requirements placed on mattresses by hygienists. Phenol disinfectants are not suitable.

Simultaneous exposure to the action of steam and heat above 110°C can cause permanent deformation of polyetheylene foam, therefore disinfection must be controlled at temperatures not exceeding 105°C (saturated steam at 0.25 kg/cm² pressure). The cover should be removed before exposing the mattress body to steam so that it will not be overstretched.

Possibilities of disinfecting mattresses

Bedside disinfection

Mattresses and bedsteads should be completely wetted with an approved disinfectant, applying a film over the entire surface. This results in disinfection only of the surface itself, as the disinfectant does not penetrate into the depth of the material. The job is done manually using a cloth soaked in disinfectant solution to rub down the mattress. If cloth mattress covers are fitted, this method is somewhat questionable, as the cloth will become wet and must then first dry, meaning that the patient is kept waiting somewhere else in the meantime. With mattress covers made of plastic there are not such problems, as they prevent wetting of the fabric. Nevertheless it is always worthwhile to consider the advantages of changing the mattress or transporting the complete bed to a separate bed service station.

Spray disinfection of mattresses is not practicable in multi-bed rooms owing to the excessive odor nuisance imposed on the occupants, but it can readily be carried out in single-bed rooms. Afterwards, the bedstead and floor must be cleaned manually.Mattress disinfection by this method can contribute to control of nosocomial infections and may be regarded as adequate except for intensive care units,burn wards and so-called life is lands.

Integration into room disinfection

In reportable infectious diseases, the patient's room must undergo terminal disinfection after the infective stage has passed. This consists of comprehensive and concurrent diinfection of all the surfaces within the room by vaporizing an appropriate disinfectant, the only effective agent for this at the present time being formaldehyde.

As a rule, such vaporizing terminal disinfection is only implemented when particular risk of infection exists or when it must be asumed that conventional scrub disinfection might not be sufficient.

The room must be prepared so that the disinfectant can properly reach all the surfaces and that none of the vapour will escape during the prescribed length of exposure. Specifically this means sealing the windows, doors and all air inlets and outlets.

Furnitures, especially cabinets,should be left standing where they are, but cabinet doors. drawer and the like must be opened. Mattresses must be propped up. Pillows,blankets and the like and clothing must be hung loosely and preferably with no folds. The room heating should be turned off or down, but temperature in the room should be kept at a minimum of 10°C.

For every cubic metre of room volume a minimum of 5 g formaldehyde (14 standard aqueous formaldehyde solution containing at least 35% formaldehyde) and 20 ml of water must be vaporized. During the necessary 6-hour exposure time, relative humidity of the air in the room should not fall below 70%.

At the end of the set length of exposure, it is advisable to chemically combine the formaldehyde by introducing vapor of boiling ammonia solution into the room. The amount required is a minimum of 0.65 ml 25% ammonia solution for every 1 ml formaldehyde solution used. Finally, the room must be thoroughly aired. The usual procedure following disinfection for the set time and subsequent neutralization with ammonia

vapor is to air the room for about one day. The mattress cover is removed and sent to the laundry together with the bed linens.

The mattress itself is left in the room if no alternative is necessary or possible. It maybe subjected to supplementary penetrating thermal disinfection.

If penetrating disinfection of mattresses, bed cloths, pillows, etc. is needed, for instance after use in an isolation ward, the problem of safely tranporting infectious material from the ward to the disinfection station and loading them in the disinfection machine is solved by a tight-closing special container mounted on wheels.

Hygiene hazards in transportation of infectious materials from any part of the hospital to the site of the disinfection equipment are ruled out by such a tight-closing special container. The closed container is wheeled into the disinfection machine on the dirty side of the central bed service station and its contents then undergo disinfection without risk of pathogenic microorganisms escaping at any point of the route from collection of the materials to unloading them on the clean side of the disinfector. In other words, it provides optimum handling of bedding used by patients with reportable infectious diseases.

After disinfection,the mattress is returned to the normal cycle of use, while the covers are sent onto the laundry before they too are finally returned to the clean side of the central bed service station.

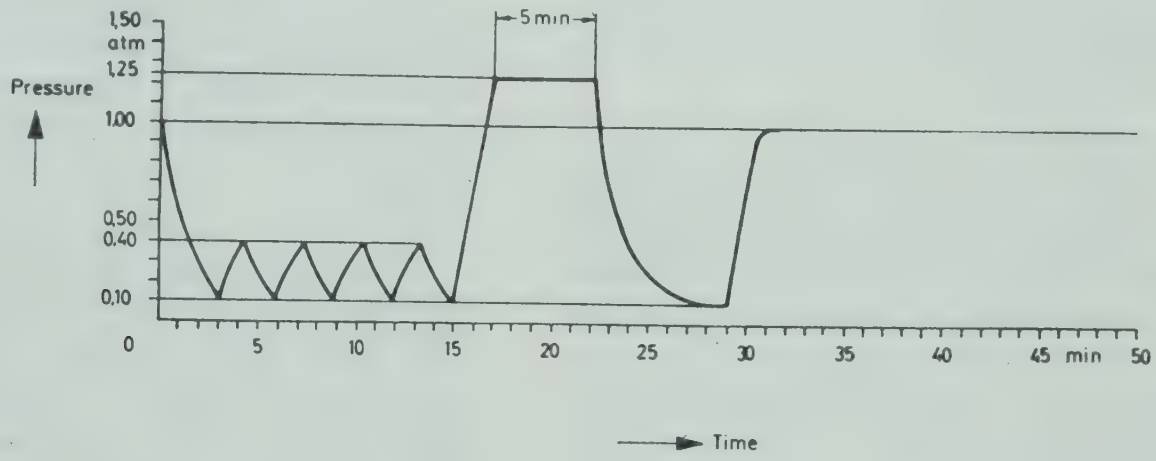

Fig. .1 Disinfection program at 105 °C for 5 minutes
Disinfection for anthrax; Category A3C

Minimizing Risk to Laboratory Personnel

Laboratory personnel are exposed to higher risk of blood-borne infection owing to handling of infective material. Specially,with increased awareness of serum hepatitis risks, and the most dreaded risk of AIDS, newer appliances to protect laboratory staff against blood borne infection are being devised.

Erthrocytic Sedimentation Rate (ESR) is one of the simplest and most common blood tests conducted throughout the world, both in developed and developing countries. A new system has been developed by which blood need not be sucked into the traditional ESR pipettes, but the specimen tube can be straight away used to determine ESR. By this, hygiene risk and waste of time is avoided.

Ref: medical focus 1/1987, pp 42

Electrotherapy Unit

Management of pain in certain intractable conditions has undergone revolutionary changes. Electrotherapy is used in management of migraine, epicondylitis and lesions of the meniscus. A portable unit delivers various forms of current for iontophoresis, short high voltage pulses or both together, as required. Current for iontophoretic treatments can be regulated from 0 to 10 mA. High voltage pulses of 0-500V are adjustable between 4 and 142 Hz and are controlled by a modulator.

This service provided at referal hospitals/clinics would prove a great boon to unfortunate sufferers of these maladies.

Ref: medical focus 1/1987, pp 46.

Recent Advances in Other Areas

28. Fecal Incontinence

Artificial anal sphincter for incontinent children

*G.H. Willital, H . Meier, U. Klotz, K. H. Dietl, G. Schlunkers**

Fecal incontinence can lead to both physical and psychic damage in children. Owing to the diverse nature of the underlying disease, the varying severity of symptoms, and the individual manner and ability of coming to terms with them, the fate of every child so affected is highly personal.

Implantation of an artificial intestinal sphincter is indicated in all children and juveniles who have a congenital or acquired dysfunction or loss of innervation of the muscular pelvic floor. In addition, such a system is suitable for all children suffering from combined partial or total loss of muscular or nervous control.

Successful management of children with these conditions is only possible on the basis of a highly motivated and cooperative partnership between patient and clinic. confidence in the attending physician and close contact with parents of children afflicted with similar conditions is exceedingly important. Lack of cooperation on either side provokes a worsening of the condition.

A study of fecal incontinent children has shown that:

- ☐ One-third of these children have an artificial anus.
- ☐ One-third of all children with meningomyeloceles regulate their bowel elimination habits by achieving controlled defecation through impaction of stool. This involves evacuation by manipulation, enema and abdominal pressure.
- ☐ One-third of all children don't acquire control of defecation despite corresponding long-term therapy.

Pyschosocial aspect

The special situation of fecal incontinent children is characterized by their frequently being dependent on care for the rest of their lives. The aim is to make them as independent as possible by practicing medical care, gymnastic training, psychological guidance and psychosocial assistance in due time.

Beyond administering organic medical attention to the patients themselves, it is essential to provide psychological and psychosocial aid to their families so as to avoid disturbed psychic developmental disorders in the children and distress within the family.

It is essential for the parents to be factually informed at birth and again preceding every therapy performed on the child in order to lay the ground for all future expectations and attitudes towards medical care and its capabilities. No less important in this connection is special training of nursing personnel along like lines with regard to treatment, care and counselling of the children and parents.

A logical consequence of this is the necessity to always involve the parents in discussions of the medical problem and the available and promising possibilities of solving them. In this way,the parents are able to both consciously and unconsciously communicate their cognitive and above all their affective attitude and approach to medical therapy applied to their needy child.

Causes of incontinence

Fundamental distinction is made among:

- ☐ Myogenic incontinence, meaning that induced by absence or under development of muscle elements, especially the sphincter ani externus, sphincter ani internus and muscles of the pelvic floor.
  This may be due to anorectal anomalies (27 different types) with abnormal development of the sacrum, e.g. sacrodysplasia,

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sacral aplasia (occuring in 6.5% of all supralevatory anorectal anomalies found on 442 children patients examined), lesions and scarring of the pelvic floor musculature, or tumors in the pelvic and rectal regions.

- Neurogenic incontinence, meaning that occuring in meningomyeloceles or tumors of the spinal cord.
- Sensory incontinence, which is due to absence or disturbance of synapses or sensory receptors in the intestinal wall or in the muscle elements enclosing the bowel with lack of feedback to the spinal cord and lack of reflex innervation of the anorectum.
- Overflow incontinence, produced by over distention of the sphincter musculature in the pelvic and anorectal regions,usually constituting a reversibly secondary pathological condition associated with megacolon, the underlying disorder for which may be for example Hirschsprung's disease or Stage 5 elongation of the sigmoid.
- Automatic rectum with incontinence, which is an abnormally increased proportion of continence-assuring muscle elements of the anorectum on accumulation of feces, for instance following resection of the rectum with preservation of the normal anal passage.

Frequency

In West Germany 430 to 450 new cases of incontinent children and juveniles annually join the approximately 4,500 already reported. These numbers evidence the importance of the problem of incontinence in children.

Fecal incontinence represents a loss of physical integrity for the person so afflicted. The inability to control defecation is a regression to an earlier stage of development causing the developing child or youth appreciable emotional stress.

International statistics for fecal incontinent children are as follows:

- Europe, 34,230
- U.S.A., 16,160
- South America, 7,380
- Japan, 7,590

Associated defects

The frequency of associated abnormalities is as stated below:

Hydrocephalus,approximately 70%, above all with meningomyeloceles in the thoracic and upper lumbar sections of the spinal cord. Skeletal system, approximately 56%, above all kyphosis, scoliosis, dislocated hip, clubfoot.

Urogenital system approximately 50% above all neurogenic bladder, vescicoureteral reflux with or without megaureters, renal dysplasia, tandem kidney, vescicointestinal fissures, hypospadias, urethral diverticula.

Deformities of the heart and large blood vessels (18%) and of the gastrointestinal system (9%).

Differentiation

Determination and differentiation of incontinence requires subtle examination technique. Not all incontinence is alike. Discounting other practicable gradings, we distinguish among a total of four stages of continence defined as TK 1 (continent), TK 2 (partially incontinent), TK 3 (partially continent), and TK 4 (incontinent).

Differentiation and objectivation of these different stages of continence allowing impartial comparison not only by clinical criteria is achieved by a series of specialized examinations.

Examination methods

These are divided into standard and specialized examinations, the former covering rectal endoscopy and x-ray contrast visualization of the intestine. This provides information on the length and lumen of the intestine, the anorectal angle and contractility in the anorectal region.

Specialized examinations

Anorectal manometry

In this, fine catheters of 2 mm diameters are inserted into the rectum in the manner of a rectal thermometer as probes to measure pressure conditions in the muscles of the pelvic floor,the region of the sphincter ani externus and the sphincter ani internus. They also measure reflex behavior in the sphincter ani internus muscle and the defecation reflex.

The examination may be compared to electrocardiography in that it does not causes stress to the patient, but interpretation is often very time-consuming. The manometric readings obtained can be compared with normal rectal values.

Functional endoscopy of the pelvic floor

This comprises assessment of the closing fac-

ully of the musculature of the pelvic floor by visual examination through a flexible pediatric endoscope which is advanced only a few centimetres into the intestine. The examiner is able to accurately assess the function of the musculature from the image displayed on a television monitor. Child and parents may participate directly in the viewing.

The standard examinations together with specialized procedures to differentiate the incontinence and the individual pedoneurological assessment required are carried out during an incontinence consultation. They then allow of individually establishing the patient's state of continence described by appropriate objectifiable results of tests. Recommendations for therapy and other consequences are based on these findings.

Possibilities of treatment

Successful treatment of fecal incontinent children is contingent upon appropriate previous diagnosis for the purpose of ascertaining the muscular functional capacity of the rectum and also the conditions of innervations in the rectum including reflex and sensory behavior.

As already mentioned, these functions can be examined by anorectal manometry and endoscopy of the pelvic floor, methods which have been specifically devised for children. They impose hardly any stress on the patients, however evalution of the results is a highly technical procedure.

Where a congenital disorder or total lack of innervation and neurological supply of the rectum is present,active closure cannot take place in the region of the pelvic floor and rectum.

Working under a research contract we have developed an artificial anal sphincter for those children who remain incontinent after all conservative therapeutical means have been attempted. Materials of this sacral sphincter (SSE) implant and its toleration by tissue are equivalent to those of cardiac pacemakers or hip endoprostheses. They have undergone exhaustive investigation and are fully suitable for implantation in children and juveniles.

Indication

Implantation of this artificial sphincter is indicated in all children and juveniles afflicted with congenital or acquired disorder or lack of innervation of the muscles of the pelvic floor. Apart from that, it is suitable for all children with combined partial or total muscular or nervous failure.

The delineation between implantation of the device and transplanation of muscle is formed by normal innervation conditions with insufficient musculature,in which cases autogenous muscle grafts appear to show good initial results. Active opening of the externally occluded intestine in the sense of relaxation of the sphincter is however not possible in these instances and irrigation is usually necessary.

An artificial sphincter is indicated for children in whom smooth or striated muscle has been surgically implanted for improvement of continence when the operation does not elicit the desired results.

Another indication is children and juveniles with meningomycloceles who suffer from profuse diarrhoea and permanent incontinence with no controlled defecation. In these patients too, the SSE implant makes possible controlled evacuation of the bowel.

Contradindication

The sacral sphincter implant is contraindicated in children when the pedoneurological assessment shows the patient to lack the mental capacity,insight and thus readiness to accept such an implant. This is the case also in children with paralysis of both lower extremities and reduced mental capacity or those who answer the physical and mental requirements but are not disposed to regular after treatment and follow-up examinations and are indifferent towards this method of treatment.

The implant is composed of two parts.

- A pair of magnetic half-rings constructed of samarium-cobalt coated with nonallergenic titanium which are placed around the rectum. They can be fitted without surgical opening of the intestine or abdominal cavity. A mechanical fastener ensures secure sitings of the system.
- The anal tampon which closes the rectum is a plug of polyvinyl formal foam with a hole through the centre to accommodate a guide pin of samarium-cobalt. Softening when it become moist, this anal tampon is stabilized in the rectum by the force of attraction between the ring magnet and the

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guide pin and is thus secured in proper position. Accumulating stool is retained inside the rectum by the tampon and liquid stools are absorbed by its porous structure. The Grillozin with which the tampon is impregnated chemically combines 99.5% of intestinal gases.

Results

The sacral sphincter implant embodies a new method of controlled defecation by the natural route of evacuation and its advantage is the technical simplicity of implantation, not entailing any surgical opening of the intestine or abdominal cavity. The operation is approached from the buttocks. In this therapeutic alternative,several demands are made on the children patients' willingness and ability to cooperate and their motivation—a fact which must be taken carefully into account when the operation is indicated.

Follow-up examination have been performed on 19 patients with organic fecal incontinence, on whom SSE implantation was carried out between 1978 and 1984. Birth of a child afflicted with a fecal continence defect was found to constitute an exceptional burden for nearly all parents, very few of whom received psychological aid for the child. In the great majority of cases the incontinence was considered the severest problem even when other abnormalities were present. The children themselves are anxious of social downgrading, with the result that 10 concealed their condition from the world outside the family.

Additional advantages experienced by children undergoing SSE implantation, and also by their families,are the improvements in hygiene and cleanliness, greater social mobility, and all that this contributes to self-assurance. Nine of the patients were very satisfied with the situation resulting from the operation, two had qualifications, and two were undecided.

Objections and apprehensions

As is common also with implantation of cardiac pacemakers, replacement or explanation of the artificial sphincter became necessary on 6 patients.

Reasons leading up to the need for explanation after a number of years are:

- ☐ Improper insertion of the tampon resulting in mechnically induced tearing of the mucosa.
- ☐ Instrumental removal and retraction of the tampon after advancing too far into the intestine performed without proper visual control, resulting in injury to the mucosa with phlegmons and abscesses necessitating removal of the device.
- ☐ Pain and discomfort or inadequate closure due to the wrong combination of tampon-endotampon relative to the intestinal diameter and size of implant.

The objections and apprehensions repeatedly heard in conneciton with implantation of the system are:

Need for replacement

As a rule, implantation is made on the school-age child. It is possible at that time to select the diameter of the anal ring system so that it will accommodate a larger intestinal lumen later on without the system having to be replaced.

Distress when seated

The ring system and the tampon are always located above the ischial plane, meaning that they will not cause discomfort,pain or other irritation when the child is seated.

Mucosal irritation by the tampon

Due to the properties of the tampon used, its excellent softness, absorbency and resilience, lesions of this kind have not been observed. By closely spaced endoscopic control we have been able to exclude reddening, swelling, bleeding or other irritation of the mucosa over a period of now eight years. In no instance was damage due to disordered blood flow observed in the course of the operative procedure and free preparation of the intestine.

Stenosis and dilatation

Repeated endoscopic examination has shown that the SSE implant does not cause either stenosis or fibrosis of the mucosa leading to constriction of the intestine. By roentgenological examinations we have demonstrated that dilatation and hypertrophy with secondary portents does not occur given regular tampon change and bowel evacuation.

Toleration

Owing to the titanium coating, the material

implanted is tolerated exceptionally well by tissue. No local or general reaction indicative of allergy, rejection or intolerance has been established on the patients operated.

Such explanations or replacements as were necessary were due to inadequate follow-up examination and control of the patients. Fundamentally, the artificial anal sphincter implantation is a simple, safe and quickly completed operation that obviates need for colostomy. It is first necessary to precisely assess the indications for implantation of the device by systematic and subtle criteria for selection. As a rule, priority will go to a number of conservative measures for correction of incontinence. The artificial anal sphincter is a therapeutic concept which enters into consideration when all other treatment for the condition has failed. Moreover it is essential for the children and juveniles who are potential recipients to be prepared to live with the system and to be able in the long run, to themselves carefully perform the daily change of tampon.

Conclusion

The sacral sphincter implant may be summarized as a means of effectively managing the hygienic, psychological and social consequences of fecal incontinence due to organic causes. Since the method is dependent to a high degree on the cooperation of patients and their families, the motivation for the cognitive and psychic conditions of those immediately affected must be explored and taken into account with extreme care when assessing indication for this method of treatment.

An indispensable requirement is that the children be able to themselves change the tampon later on and also be able to learn to do so. Frequency of tampon change is individual and should be once or twice daily after a period of adaptation. The children must be sufficiently familiarized with the system and must from the start take a positive attitude towards it.

It has been found successful to medically supervise the patients by regular outpatient control examinations at three-monthly intervals. During these visits we make endoscopic examination of the rectum for the purpose of early detection of possible iatrogenic lesions, which are avoidable.

Another important requirement is comprehensive guidance in introduction of the anal tampon. Especially in children with innervation disorders in the rectal regions, a too abrupt and inexpert approach can result in mechanical lesions to the intestinal mucosa when the tampon is advanced.

Inner ear Prosthesis

Internal ear disease leading to hearing impairment need no longer handicap the sufferer. An eight-channel inner ear prosthesis consisting of a cochlear implant, and an (externally worn) hearing stimulator, has been devised. After implementation, the two systems can be linked either percutaneously by means of a connector or transcutaneously by high frequency.

The cochlear implant consists of a plastic capsule containing all the necessary electronic and electrical circuitry in a water proof enclosure which leads to the eight pole electrode plate. The plastic capsule is implanted in a recess milled in the bony mastoid process, and the electrode plate is fixed on the bony wall covering the inner ear, without having to open the cavities of the inner ear. The operation almost corresponds to a routine middle ear procedure. The hearing stimulator converts sound into an eight channel electrical stimulation pattern. High tones trigger off stimulation pulses which are conducted to the basally located stimulation electrodes; this is complemented by stimulation of the helicotrema.

Ref: medical focus, 5/1986 pp 32

29. Catheter techniques

Safe placement of catheters in emergency situations

*R. Nessler**

Central venous catheters are indispensable instruments in all clinical therapeutic and diagnostic procedures of emergency and intensive care. In emergency conditions the route which should be chosen for catheterization is that affording the quickest and most reliable introduction through the superior vena cava. Accuracy of placement is dependent not only on the given anatomical conditions and external circumstances, but also on the technical skills and experience of the attending physician.

In emergency venipuncture or catheterization the innominate vein provides a suitable route of access to the superior vena cava. Emergency incision of the innominate vein demonstrates a high score of accuracy (93%) while taking little time. Table 1 lists the shock and emergency conditions in which puncturing of the innominate vein has been practised.

Indications

Emergencies

Emergency situations in which catherterization of the vena cava is indicated are:

- ☐ Shock with collapse of peripheral veins
- ☐ Impossibility of venipuncture at other sites
- ☐ Necessity for immediate measurement of CVP
- ☐ Acute hemodialysis
- ☐ Administration of highly effective drugs close to the heart in the reanimation phase.

Parenteral nutrition over an extended [period of time is similarly an absolute indication for placement of a central venous catheter, as in the instillation of infusion solutions having an osmolarity greater than 900 millimoles per litre.

Infusions

Indications for medium and long term infusion therapy via a vena cava catheter are:

- ☐ Parenteral nutrition with hypertonic solutions
- ☐ Continuous monitoring of CVP
- ☐ Regular and frequent withdrawal of blood samples with impossible surface veins
- ☐ Reducing risk of thrombosis (large lumen vein)
- ☐ Provision for long-term administration of high-efficacy drugs

Readings of the central venous pressure are particularly valuable in critical circulatory conditions. Placement of a central venous catheter and the possibility it affords of measuring CVP contributes to a considerably better possibility of maintaining accurate fluid balance in severe hypovolemia and in high-risk cardiac and renal conditions

Anesthesia for catheterization

The forms of anesthesia listed in Table 2 have been applied for the internal jugular vein and innominate vein on patients undergoing surgery. With adult patients, the form of anesthesia varies; with children sedation should be applied almost exclusively. Approximately 60% of all central venous catheters were placed in direct association with general anesthesia. About 10% were inserted under local anesthesia and 27% in the waking state without anesthetization (indirect technique). For the most part, catheterization under general anesthesia was for the purposes of postoperative treatment. The instances in which catheters were placed under local anesthesia or without anesthetization mainly concerned preoperative infusion and diagnostic or therapeutic measures associated with intensive care. Use of the atraumatic indirect techniques (Alpha system*) permitted non anesthesized catheterization in numerous cases.

Access routes

Introduction of a catheter into the superior

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vena cava via the so-called central veins is preferable to peripheral venipuncture with a view of reducing long term complications such as phlebitis, thrombosis and sepsis. Problems are not to be anticipated when puncturing or catheterizing the veins close to the cava unless they are caused by any of the following conditions:

- ☐ Inadequate positioning of patient
- ☐ Selection of an unsuitable access route
- ☐ Use of traumatic catheter systems
- ☐ Catheterization systems that are not proof against misplacement (i.e., which do not contain a stable-guiding mandrin)

In routine clinical work the innominate and internal jugular veins have proved to be suitable paths for accessing the superior vena cava.

Innominate vein

The right and left innominate or brachiocephalic veins collect blood draining from the veins of the head, neck and arms. They are valveless and are formed posterior to the sternoclavicular joint by the juncture of the internal jugular and subclavian veins, respectively right and left. At the medial end and caudal edge of the first right costal cartilage the innominate veins join into the superior vena cava

Due to their anatomical position, their fixation to adjacent organs by connective tissue and their large internal diameter, the innominate valves afford an optimal access route in emergencies by providing a ample passage that is always open even in a state of severe shock. Moreover the abundant lumen and the short, straight course ensure favorable conditions for indwelling catheterization.

Puncturing of the innominate vein

Exact analysis of the puncture site and the respective anatomical conditions in combination with reproducible criteria assure unproblematical incision and thus preclude complications in catheterization.

Prior to veinpuncture the patient is placed in recumbent position with the upper arm on the operative side against the chest and the shoulder drawn slightly down. The head is turned to the opposite slide and the claviculomastoid angle is localized in the lateral triangle of the neck. The puncture site is approximately 2 cm dorsal to the apex of the angle formed by the clavicle and the lateral edge of the sternocleidomastoid muscle.

The cannula is pointed in a direction almost parallel to the clavicle on the right and directly parallel to the clavicle on the left. The angle to the frontal plane of the needle as it is advanced from dorsal to ventral in the direction of the jugular fossa is about 20 degrees. After penetrating about 3 to 4 cm, the cannula hits the innominate vein.

Internal jugular vein

The internal jugular vein lies directly adjacent to the common carotid artery and internal carotid artery after emerging from the base of the skull. The vein runs lateral to the carotid artery and slightly closer to the surface and is crossed from dorsocranial to ventrocaudal by the sternocleidomastoid muscle. It continues dorsal to the sternoclavicular joint, joins the right subclavian vein, and then joins the right subclavian vein, and then merges into the right innominate vein without change of direction. The left internal jugular vein merges into the innominate vein in an S-curve.

The site of puncture on the internal jugular vein lies approximately 1 cm lateral to the artery on a level with the incisura of the thyroid cartilage.

The cannula is introduced at an angle of 30 to 40 degrees to the skin (right to left) and advanced in th direction of the transition between the inner and middle third of the clavicle. After overcoming a usually slight resistance of muscle or muscle fascia (transmuscular approach), the cannula reaches the internal jugular vein in a depth of 3 to 4 cm.

Superior vena cava

Once the innominate or internal jugular vein has been punctured, catheterization is made by the indirect technique with no appreciable difficulties.

Application of the indirect technique using a plastic mandrin for catheterization of the superior vena cava provides considerable advantages over the direct catheter-through-cannula method:

- ☐ The indirect technique allows of using small-bore cannulas for vein-puncture, thus assuring atraumatic incision.
- ☐ Due to optimum guiding of the catheter by the plastic mandrin, all damage to the catheter through coiling or kinking is avoided. Risk of tearing of the catheter re-

sulting in embolism is eliminated, and the catheter does not come into contact with the cannula.

- ☐ Misplacement is prevented by reliable guiding of the catheter over the mandrin.

Table 1: Classification of 1,000 emergencies treated with puncture or catheterization of the innominate vein showing score of exact placement (figures originating in part from studies under a large-scale international test)

No. of cases	Emergency treated	Exact placement	Score %
135	Hemorrhage	130	96
40	Extensive burns	39	98
135	Cardiogenic shock	126	94
275	Severe craniocerebral trauma	255	93
415	Severe shock due to other causes	380	92

- ☐ Standardized catheter lengths help to prevent intracardiac misplacement.

Catheterization of the superior vena cava proof against misplacement by using plastic mandrins and catheters inset or marked lengths is a prerequisite to safe administration of hyperosmotic infusion solutions and accurate measurement of central venous pressure.

Table 2: Forms of anesthesia applied in 5,997 catheterizations of the internal jugular vein and 4,010 catheterizations of the innominate vein (figures originating in part from studies under a large-scale international test)

Form of anesthesia	Right internal jugular vein	Left internal jugular vein	Right innominate vein	Left innominate vein
Local	2501	530	384	11
General	1755	353	2245	65
Sedation	178	38	-	-
Unconscious	124	28	216	9
Conscious non-anesthetized	400	90	1046	34

Chemoembolization to treat liver cancer

The double blood supply of the liver, through the hepatic artery and the portal vein permits this technology to be utilized for treatment of unresectable cancers of the liver. Gelfoam particles are injected along with the chemotherapeutic agent doxorubicin, mitomycin-C, and cisplatin, directly into the hepatic artery. After a few seconds the gelfoam particles jam up the artery. The drug remains in contact with the tumor for days (instead of for a few hours as with intravenous chemotherapy). The Gelfoam "dam" is harmlessly absorbed by the body within 2-3 days. Remarkable reduction in size of tumor, and in some instances long-term survival, has been noted. One advantage of this kind of treatment is that it requires hospitalisation only once in three to four months for therapy. Follow-up care subsequently, could be maintained on an out-patient basis.

Ref: Hospimedica 12/1988, Vol. VI, No.7, pp.6

Breast scanning system

Breast cancer is a major killer among cancers in women. There is increasing awareness among women the world over about the risk of breast cancer which strikes mostly in middle age posing a risk to an otherwise long life expectancy of women. Awareness of advantages of early detection with possible hopes of cure makes many women present themselves for routine scanning; in addition large numbers of women with benign breast pathology attend referral hospitals/medical college hospitals/ cancer clinics,and they have to be preferably offered a non-invasive, simple diagnostic procedure, which could be applied on a large scale.

Light scanning of the breast is one such technique. The breast is illuminated with low-intensity light, and the transmission pattern of narrow bands of red and infrared light is detected, amplified reconstructed and displayed in visual wavelengths. The image is recorded/displayed via a special video system, the image being controlled by a computer, which allows areas that transilluminate differently to be viewed as varying shades of grey or tones of colour. If a real time ultrasound unit is integrated with the light scanner, the result is a composite unit that ensures complete breast scanning capability.

Ref: medical focus, 5/1986, pp 30

30. Otoscope set

For the specialist and general practitioner

A basic diagnostic instrument for examination of the ears, the otoscope permits direct viewing of the auditory canal and tympanic membrane yielding information of value to the physician which cannot be obtained by other means. It is designed for the needs of both specialists and general practitioners.

Considerable attention has been invested in making the set compact, light and altogether portable. It is easy to use and the only maintenance required is occasional cleaning of the magnifying lens and recharging or replacement of the batteries when necessary. The component parts are:

- ☐ Otoscope head fitted with an 8.5 D magnifying lens
- ☐ Handle containing a rechargeable storage battery or expendable primary batteries.
- ☐ Assortment of interchangeable speculums stored in a box

Otoscope head

Advantages of the otoscope head are the high brilliance and shadow-free illumination of the area observed and a smooth duct which affords a direct view, magnified about three times, of the structure examined with no obstruction by any internal leads or the like. This results from use of a fibreoptic bundle encircling the distal end of the duct on the outside,through which light is transmitted from the lamp mounted in the connector of the head, while the viewing duct itself is kept entirely free

Power handle

The handle of the otoscope is designed to take either nicad rechargeable batteries or dry or alkaline batteries, with a choice of two sizes to accommodate three C batteries or two AA batteries. It is fitted with a hot foot for recharging an internal storage battery with a special charger even while the otoscope head is attached. Electronic circuitry inside the handle actuates external indicators to tell when the instrument is switched on and when the battery needs charging. Adjustment of power to produce the required level of illumination is made on a ring knob which controls a variable resistor.

Specula

The standard set of specula covers the full range from 3 to 7 mm internal diameter. Their distal ends are rounded to avoid injury to the ear during examination. On opening the box in which they are stored,the specula are lifted by an internal spring so that they can snap conveniently onto the otoscope head. They do not need to be touched by hand either when fitting or removing. Specula are available in constructions of plastic (polypropylene) for one-time use and me-tal for resterilization.

For specialists the otoscope set is available as part of a complete ENT examination outfit which fully comprises the following items:

- Otoscope head
- ☐ Ophthalmoscope head
- ☐ Laryngoscope head
- ☐ Power handles in two sizes
- ☐ Battery charger
- ☐ Wall-mounting power supply to be used
- ☐ with all examination heads instead of the portable power handles
- Cold light projector to supply cold light to
- ☐ the heads through fibreoptic cables longer than 1 m.

Simple bayonet-type connectors are fitted to all parts of the set.

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Meniere's Disease - Advances in treatment

Meniere's disease characterised by tinnitus, and vertigo (sometimes so severe as to make the patient fall to the ground), sometime advancing to deafness, affects an estimated two million people the world over. Repeated exchange of plasma (presumably by eliminating certain antibodies) has been shown to result in improvement among some patients. With standardization of this procedure, victims of the disease could expect relief from the distressing symptoms, and possibly escape permanent hearing loss.

Ref: medical focus, 6/1986, pp 5

31.Recent Advances in-Opthalmology

*Dr. Sudha Xirasagar**

1. Loss of vision is among the most tragic of handicaps compatible with life. Injury or degeneration of the anterior parts of the eye like the lens, cornea, etc., have been tackled for many decades now: surgical and medical treatment of these conditions is sufficiently advanced to restore normal or near normal vision. The difficult challenges to ophthalmologists have been posed by disease or disruption of structures behind the lens-viz-a-viz the vitreous body and retina.

2. Retinal tissue being an outgrowth of the central nervous system in its embryonic development, cannot be regenerated by the body if it is once destroyed. Apart from the primary degenerative processes affecting the retina, majority of cases with retinal problems are due to, either physical disruption from its position leading to secondary lack of blood supply,or degenerations as a sequel to diseases like diabetes which affect its blood supply. Besides, a hole in the retina or tears caused by degenerative changes or trauma, can lead to total detachment of retina and therefore blindness.

3. Recent advances in opthalmology include increasing sophistication of instrumentation and technology to improve success rates in treatment of retinal and vitreous conditions. Retinal holes or tears can now be successfully managed by surgery. A plastic material (solid silicone rubber implant) is attached to the sclera to create a hump which brings the choroid in apposition with the retina. To anchor the retina to the choroid, cryotherapy (cold application) or diatheromy is used to "weld" them together through creating a circular scar. With advanced vitreous surgery using a retinal brush, retinal tacks, silicone oil and endo laser, the success rate of surgical treatment of retinal transplants has been greatly improved. In selected cases of imminent retinal detachment due to formation of vitreous bands especially common in diabetics, the yag laser is used to selectively cut the bands and halt the process of stretching which would lead to detachment of the retina and blindness.

4. Retinal imaging techniques recently introduced to assess the retina include flourescein fundus am (FFA), ultrasonography and Visually Evoked Response. In the flourescein angiogram, photographs of the fundus following injection of a dye, fluorescein, gives an indication of localised and generalised compromise to the blood supply of the retina, and shows up areas of neovascularization. Ultrasonography is used to study changes in the vitreous cavity.

5. Photocoagulation is a technique by which powerful light rays are focussed on to a tiny spot in the retina - spots where new blood vessels are formed in diabetic retinopathy or Eale's disease (which can potentially give rise to vitreous haemorrhage). The light on striking the target area is converted to heat which cauterizes or seals off the abnormal blood vessels. With increasing detection of diabetes in the population and prolonged/near normal life expectancy for well-controlled diabetics, there is increasing incidence of diabetic retinopathy. In developed nations and also in developing countries, many diabetics have been spared vitreous hamorhages, retinal detachment and the ensuing blindness,by this technique. Laser photocoagulation has improved the accuracy and efficacy of this technique in preventing vitreous haemorrhage.

6. Vitrectomy is a new operation which is being carried out for diabetic retinopathy. Formerly once vitreous haemmorhage (and blindness) had occured the prognosis was considered hopeless and the eye was given up for a permanently blind eye . Today the opaque vitreous can be removed and replaced. Advances in instrumentation that have made this possible include vitreous infusion section cutter (VISC), yag laser, etc.

7. Endolaser photocoagulation combined with advances in instrumentation techniques, even to freely work surgically within the vitreous chamber, now make it possible for ophthalmologists even to save a severely traumatized eye, a feat which would have been considered impossible

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barely two decades ago. Similarly vitreous surgery, which has developed into an independent discipline, can now remove pus, introduce potent antibiotics and save an eye affected with endophthalmitis which sometimes follows eye surgery or trauma.

8. The most recalcitrant of problems - the primary retinal degenerative conditions like senile macular degeneration, retinitis pigmentosa, etc, are now being attacked by attempts to transplant the retina. It is estimated that retinal transplants will be able to offer vision to persons afflicted by these conditions within five to ten years.

Ref: S. Natarajan, 1989 A Peep Into the Eye,Science Express, October 3, 1989.

Ultrasound Biometry - Aid for Artificial Lens Implant

Artificial lens implantation after cataract extraction has gained world wide popularity. Accurate calculation of the refractive index of the plastic lens to be implanted is crucial for restoration of normal vision. Ophthalmic ultrasound biometry enables measurement of the length of the eyeball within an error of 0.15 mm. This enables calculation of appropriate refractive index for the particular patient, by a non-invasive technique.

Source : medical focus, 2/1988, pp 20-22.

Engineering Criteria for Hospital Lighting

Modern hospitals are highly capital intensive in order to be well-equipped to provide the best possible health care. Highly qualified specialists man these hospitals to tackle even those health problems hitherto considered beyond human efforts, with the help of the most sophisticated equipment. Most unfortunately however, architectural aspects of hospitals including floor space areas of different types of areas, lighting aspects, etc. are neglected. An accident occuring to an elderly or handicapped individual owing to these factors could be of grievous import, and tarnish with one stroke, the image of the hospital. Normally, illumination required for examination and treatment areas, service and administration areas, etc., is well provided. However, general purpose areas like stairways, bathrooms, patient waiting rooms, corridors,etc are often neglected, because no special medical procedure is carried out here. Architectural standards for optimal lighting of different types of general purpose areas have been laid down, taking into account several engineering and visual aspects. In the design of hospitals, these factors should be taken into account to ensure maximum safety.

Source: medical focus, 1/1985, pp 58-62.

32. Technology and Mental Health

*Dr. G.N. Narayana Reddy**

I Introduction

Mental health has been a neglected subject because of many misconceptions which are being eradicated gradually. The important misconceptions are: (1) prevalence rate of mental illness is low in developing countries and occur mostly in sophisticated industrialised population. It is not a problem in developing countries, particularly rural areas, (2) the second misconception is that mental disorders are due to a curse or possession of demon/devils and black magic methods only, (3) the third misconception is that there is no treatment. If once the illness comes, it will be a life long disease without any cure, and (4) fourthly that any treatment given for these diseases should be by a highly sophisticated person and requires specialised training.

These misconceptions are being proved wrong. The prevalence rate as per the epidemiological study done in developing countries, both in urban and rural areas indicate that there is no difference between the developed and developing countries or between the urban and rural areas. A number of studies done in different parts of India clearly indicate that 1% of the population suffer from mental illness and nearly 15 to 20 per cent suffer from minor psychological disturbances. The cause of mental illness, is not very clear; the increasing advances in the field of medicine particularly the neurosciences have revealed that there is a definite biological factor in addition to psycho-social factors for the development of psychiatric disturbances. During the past 50 years, with the advent of pharmacological treatment a number of drugs have been available to treat these patients. It is possible to control any excited patient within a few hours. Similarly the mood of the depressive patients can be elevated in a matter of few days. The combination of pharmacotherapy as well as the psychosocial interventions will help a number of psychiatric patients, and if patients are treated early, more than 60% of patients can be cured and majority of them can go back to normal activities. The care of the mentally ill was isolated earlier from the general medical approach. The care of the psychiatric patients can be provided in the general hospitals and further, various studies have shown that they could be treated at primary health care level with a community approach.

II Technologies Advances

The technology required in the management of mental illness is being developed utilising the present knowledge of scientific advances. The most important progress that has been made during recent times is that of acquisition of knowledge about mental illness and their management. The specialists are able to understand the causative aspects of mental illness as well as the disease process itself. The new sophisticated methodologies developed in the field of psychology, sociology and neurobiology are being available in most of the specialised centres. The functioning of the brain and structural changes that occur in organic psychosis are being understood with the use of computerised tomography (C.T. scan) and recently, use of magnetic resonance imaging (MRI) as well as Positron Emission Tomography(PET). Some of the equipments like spectrophotometer, chromatography etc. have helped in the understanding of biological changes that occur in psychiatric patients as well as in monitoring of drugs to assess the blood levels in patients. Further, to study the electrophysiological changes that occur in the brain during health and disease, the new sophisticated technology of Electroencephalography (EEG) with Telemetry and computerisation has been developed so that the study could be done both while awake as well as during sleep. These sophisticated technologies are required for difficult and problematic patients as well as for research purposes. For routine assessment of mental illness these equipments are not necessary.

The mental health professionals have developed new approaches to transfer the knowledge and technical skills of identifying the problems and also manage these psychologically disturbed patients. Manuals of instruction have been developed for doctors and health workers providing primary health care. The two weeks orientation training programme for General Medical Practi-

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tioners has been developed with clearcut curriculum and syllabus. Similarly one week training programme has been developed for health workers. The tasks of health workers are:

(1) management of psychiatric emergencies (e.g. acute excitement, crisis situation) through simple crisis management skills and appropriate utilisation of specified medicines.

(2) administration and supervision of maintenance treatment for chronic psychiatric conditions in accordance with guidance by the supervisors,

(3) recognition and management of grandmal epilepsy (particularly in children) through utilization of appropriate medicines under the guidance of a medical doctor,

(4) liaison with the local school teacher and parents in matters concerning the management of children with mental retardation and behaviour problems,

(5) counselling in problems related to alcohol and drug abuse.

The tasks of Primary health centre doctor or general practioner are:

(1) Supervision of the MPW's performance of specified mental health tasks,

(2) elementary diagnostic assessment of cases, using diagnostic and management flow-charts, and performing a standardized basic neurological examination,

(3) treatment of functional psychosis,

(4) treatment of uncomplicated cases of psychiatric disturbances associated with physical diseases like malaria, typhoid, mild to moderately severe depressive states, anxiety syndromes and initial stages of functional psychoses with appropriate drugs.

(5) management of uncomplicated psychosocial problems without use of drugs,

(6) epidemiological surveillance of mental morbidity in the area and compilation of estimates of needs which would be submitted periodically to the next echelon for review and planning future services. In a way similar to the MPW's method of work, the medical officer will be guided by specified cutoff points for referral of problems to a higher level of health service set-up.

The evaluation of these training programmes as well as the effectiveness in the field has been done at an interval of 18 months to three years. This programme of integrating mental health with general health care is being implemented during the past seven years. The assessment of this has revealed the possibility as well as the feasibility of providing mental health care at the periphery, using mainly pharmacotherapy with simple psychosocial interventions to involve the members of the family and the community. In view of the successful experiments, this approach has been adopted as National Mental Health Programme to provide mental health care all over the country. The requirement of technology at the primary health care level is very minimal and with the present technology in the general health care, mental health care also can be provided.

During the past three decades it has been shown by various studies that the care of the mentally ill in the community is more beneficial than in the isolated mental hospitals. The old concept of custodial care, isolating the patients from the society has been changed. A number of studies have shown clearly that mental patients will recover faster if they are treated in the community. In number of countries the mental hospitals have been or being abolished. However, the present thinking is that there is a role for mental hospitals to look after the chronic distrubed patients and to provide models of managements including rehabilitation. Many severe and highly excited patients could be taken care of for two or three weeks in mental hospitals and discharged for care in the community. Some of these patients may require to go through the half-way homes before they could go back to the families and to their work. The best technology for the management of psychiatric patients is to treat them with the family so that the family members could be educated and provided simple skills to look after these disturbed patients. The mental health skills have been simplified for a lay man to learn and also to change their attitudes. The important factor of attitudinal change in the management of these patients has been highlighted. This will not only help in quick recovery of the patients but also in preventing relapse. The burden on the family

and the community will be reduced by this approach.

World Health Organisation has produced number of documents on prevention of mental illness, promotion of mental health and management of psychiatric disorders. At present efforts are being made to understand and develop effective methodologies and skills in the management of these patients at different levels of primary, secondary and tertiary care.

While these approaches are proving effective in dealing with severe mental disorders, the minor psychological problems such as different varieties of neuroses,drug dependence, and alcoholism are on the increase. Psycho-social intervention techniques have been developed to deal with this variety of problems. New approaches of mental health skills have been developed to cope with stresses and strains. The need for change in individual attitudes and life style to promote positive mental health is being highlighted and W.H.O. has brought out a booklet on prevention of mental, neurological and psychosocial disorders (W.H.O., 1986, EVA-88.1 Geneva).

Behavioural therapy

New technology, developed in the field of biofeedback using number of equipments are in vogue in the management of neurotic patients. This technique utilises the physical changes occurring in states like anxiety, phobia, tension etc. The increase in the pulse rate, skin temperature, blood pressure, respiratory rate, tension of muscles are used to feed the individual that the person is not relaxed, and helps in practicing the instructions to alleviate the anxiety, unfounded fear and tension etc. Based on this principle, behavioural therapy has been evolved, to treat number of minor psychological disorders including drug dependency, alcoholism, sexual deviant behaviour and tics. The subject or patient is trained over several sessions to alter the physiological state for overall relaxation and thus alleviate the symptoms.

Neuropsychology

Experimental neuropsychology provides an interface between psychological functions like attention, perception, regulation of voluntary motor behaviour and emotions with physiological states. Physiological state may be measured by electrophysiological techniques, endocrine functions, cerebral blood flow and metabolic changes in the brain. Of these, electrophysiological techniques are most commonly applied as several noninvasive techniques are available which can be applied in human beings, normal, or with abnormal conditions. Most widely used electrophysiological methods are computed EEG analysis, and event-related potential studies. The effort is not to derive or arrive at physiological correlates of psychological states, but to develop psychophysiological models of behaviour, by integrating neurophysiology,neuroanatomy with psychology. It may be noted that electrophysiology has made a quantum jump by applications of computer technology.

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33. Mental Health In India: Morbidity Patterns And Modern Treatment Techniques

*Dr Ashok Sahni**

The mental health of a nation is influenced by mental health of its citizens— the individuals and groups, constituting a nation. The present morbidity patterns and the resources in India suggest that mental health will be a major health problem facing the planners, administrators and professionals in India. This paper briefly reviews the present mental health morbidity patterns and discusses the modern treatment techniques.

I. Concept of Mental Health

In 1946 the World Health Organization defined health as "a state of complete physical, mental and social well-being, and not merely an absence of disease or infirmity". Mental health and social well-being were given importance equal to that of physical health. It marks a new era where the study of the human mind and its pathology would be lifted into the realm of the legitimate, out of darkness and the realm of ignorance. In short, the previously existing dichotomy between mind and body was dismissed. People began to understand that man's continued existence on this earth, in a healthy state, is dependent on his having a healthy body and mind.

India was one of the countries which attended the world body sittings that evolved the above definition of health. The time had come when India had to give serious thought to the nation's mental health. The problems of the country were enormous and the statistics were staggering. In a country, however, where the population numbered in the hundreds of millions, with high illiteracy rates, oppressed by disease and poverty, and emerging from two centuries of foreign domination, it is clear that mental health might not be given top priority.

"Mental health" is a difficult concept to define. Every group or individual has a slightly different idea of what this concept means. The WHO, which proposed the definition of health quoted at the beginning of this paper, has this to say:

"Good mental health is a condition which permits the optimal development of the physical, intellectual and emotional needs of the individual, so far as this is compatible with that of other individuals. . . . . A good society is one that allows this development of its members while at the same time ensuring its own development and being tolerant of other societies".[1]

II. Current Status of Mental Health in India

This section on the current status of mental health in India will be divided into two parts. The first will review the estimates of prevalence and current psychological morbidity statistics. The second part will examine the prevalence of psychosomatic disorders.

A. *Psychological Morbidity*

To understand the magnitude of a problem, in any medical speciality and especially in psychiatry and the allied behavioural sciences, the fundamental requirement is a large scale epidemiological study which can give us data about a particular disease in a given population. A number of epidemiological studies in the area of mental health have been done in various places in India. The results of these studies are highly variable. Some variance is due to differences in the characteristics of the study population (urban and rural, southern and northern). Some of the discrepancies may be the result of sampling techniques or sample size.

The largest study of a mixed urban and rural population was done by Dube[4] in Agra. The study estimated the prevalence of mental illness at 23.8/1000 population.

Sethi et al[5], surveying 75,892 urban residents near Lucknow found a prevalence of 67.3/1000. This figure included neurosis, mental retardation and major affective disorders, The same investigators found a prevalence of 39.4/1000 in a rural population of 2551.

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Abraham Verghese[6] in Vellore found a prevalence of 66.5/1000 in the urban population and 61/1000 in the rural. These figures indicate a higher prevalence of mental health problems in India with the greatest prevalence being among urban dwellers.

According to Wig[7] there were about 13 million persons India who suffered from different types of mental illness. Ganguli[8] studied a ten percent sample of textile workers in a factory in Delhi and found a prevalence of 125/1000 for psychoneurosis and of 140/1000 for all types of psychiatric disorders. According to a 1971 WHO report[9], there were more than 5 million seriously psychotic people in India who received no form of western medical aid and at least another 5 million severely subnormal children and adults.

According to K A Kumar,[10] Professor and Head of the Department of Psychiatry, Trivandrum Medical College, there are 7.2 million suffering from mental disorders.

Table A summarizes the findings of some of the major studies that have been done in India over the past twenty years. While these studies do represent a diverse sampling of the population, they are not comprehensive in their representation. It is clear that the results would need to be substantiated by more broad-based examinations of the problem. Even if one accepts the lowest estimates of mental morbidity as correct, the problem is of tremendous magnitude.

Other studies have been done to study the relationship between migration and psychiatric illness. This relationship is important in India where there is currently a migration from the rural to the urban areas. Dube[4] and Sethi et al[11] have shown that psychiatric illnesses were more prevalent among immigrants than among natives. This pattern persisted after 30 years of observations. Bhaskaran et.al[12] found psychiatric morbidity to be higher in their migrated industrial population. In their sample of 200 industrial workers at Ranchi, they found a prevalence rate of 370/1000 for migrant workers and 150/1000 for the non-migrant workers. It is clear that migration adds to the stress level and, therefore, perhaps to the psychiatric morbidity of the individuals involved.

Mental retardation is also a major problem in India. It is estimated that there are between 15 and 22 million retarded persons in the country presently.

The rate of suicide is increasing every year. According to a WHO estimate, 110 out of every 1000 suicides in the world occur in India. Studies done by Venkoba Rao and Paul[13] show that suicide rates increased between 1961 and 1971. The ratio of attempted to completed suicides worsened from 1:12 to 1:9 in Madurai. A report published in "The Hindu" on December 12, 1989 showed a suicide incidence rate of 5.5/1000 population in Gujarat. The highest rate was among people 20-29 years of age. In the same study the ratio of female to male suicide was 1:2 to 1:0.

B. Psychosomatic Illness

As seen in the previous section, the incidence of mental illness is high in India. As the society faces more and more stresses the prevalence is likely to increase. The problem is of a larger magnitude if we consider not only those disorders diagnosed as mental illness (e.g. psychosis, neurosis, alcoholism, retardation), but include psychosomatic disorders as well. These are physical illnesses that have their roots in psychological distress.

The current literature distinguishes three stages at which emotional/psychological disturbances can effect the physiological manifestation of disease.

1) Predisposition
2) Perpetuation
3) Precipitation

Psychosomatic disorders are also classified according to the organ system affected (e.g. musculo-skeletal, respiratory, cardiovascular, etc.). Some of the more common diseases assumed to be, in many cases, psychological in origin or perpetuation are hypertension, asthma, dermatitis, headaches and diabetes.

A number of techniques are used to assess the degree and sorts of psychological disturbances that precede or aggravate somatic disorders. Detailed family and life histories are taken. Chemical and psychiatric evaluations are done, often with the help of comprehensive scales which rank and classify the nature of the disorders.

The results of many studies on psychosomatic disorders were reported by Sethi et al[14]. Symptoms of psychological disorder were observed in forty-five percent of asthmatic patients. Signifi-

TABLE A: Prevalence of Mental Morbidity in India
(Prevalence: Number of cases/one thousand population)

Investigators	Year	Place	Population Studied	Prevalence of Morbidity										
				Schizophrenia	Epilepsy	Depression	Organic psychosis	Neurosis	Personality disorder	Alcohol/ drug	Mental Retardt.	Children's disorders	Others	Total
N C Surya et.al.	1964	Pondicherry	2731	1.5	2.2					3.6	0.7		1.5	9.5
P S Gopinath	1968	Sakalevara (Bangalore)	423	7.1	2.86					2.36	4.72			17.04
H C Ganguli	1968	Delhi	327		8			125				12		133 (adults)
B B Sethi et.al.	1967	Lucknow (Urban)	75892	2.3		6.9		24.8			22.5		10.8	76.3
B B Sethi	1972	Lucknow (Rural)	2551	1.1.		1.5		5.2			25.3		6.3	39.4
K C Dube	1970	Agra	29468	2.17	3.19	1.26	.85	8.87					7.45	23.79
M N Elnagar et.al.	1971	Nashbin (W.Bengal)	1383	4.3	4.3	2.9		1.4		13	1.4			27
D M Pandi et.al.	1975	W.Bengal	1080	2.83	10.38	37.37	—	30.29	—		—	2.8	2.83	—
G M Carstains R L Kapur	1976	Kota (Karnataka)	1289	10 (psychosis)		29.2		200						244.6
A Verghese et. al.	1973	Vellore (urban)	2904	2.6		2.6	2.6	48.3	1.6	4.8	20.8	49.2		66.5 (adults)
K Subramanyan A Verghese	1978	Vellore (rural)	378					2.65		15.9	42.4			61 (adults)
M K Issac	1978	Attibele (Bangalore)	2232	3.58 (psychosis)	5.72	13.89		55.12		2.68				80.97

cantly high rates of neuroticism among skin patients were found when compared to a control group. Bagadia[15] reported high degree of psychiatric morbidity preceding the onset of diabetes in his Indian population. This morbidity was in the form of depression and anxiety neurosis.

Dhirwani[16] has also been studying diabetics. Observing the emotional problems in the cases of 10,000 diabetics he has found that 4890 lost one or both of their parents during childhood. Parental maladjustment of significant degree was found in nine of the cases. The majority of his cases came from single unit families. Clinical evaluations of these patients showed that in 8690 there was manifest psychiatric illness that preceded diabetic symptomatology.

Chandrasekar[17] correlated asthmatic attacks with parental loss or deprivation during childhood. He reports that emotional factors can trigger asthmatic attacks by reflex activation of the vagus afferent pathways.

As Indians are faced with increased stress due to changes in the social structure and migration to the urban centres we can expect to witness an increase in the incidence of psychosomatic illness. Combined with the increasing incidence of psychiatric illnesses the numbers become staggering. It is clear that something must be done to address this growing problem in the area of mental health. How well prepared is India to handle this problem? In order to assess this we must look at the available treatments and resources, as well as the obstacles that stand in the way.

III Modern Treatment Techniques

Treatments for mental abnormalities can be divided into the following five general categories: 1) Pharmacological and Physical; 2) Psychological or Psycho-therapies; 3) Behavioural; 4) Social Manipulations; and 5) Traditional. The treatment can either be administered on an outpatient or, in what are often more severe cases, on an inpatient basis.

The advent of drugs and physical methods of treatment has revolutionized the treatment of many psychiatric conditions. While at one time, until about thirty years ago, people who suffered from acute psychiatric disorders (e.g. schizophrenia or manic depressive psychosis) were destined to life long misery and suffering either in institutions or on the streets, they can now be treated with various drug therapies. As a result of pharmacological advances in psychiatry, hospitalization can be reduced and patients can function normally and lead productive lives.

In 1938 Cerletti and Bin introduced Electro Convulsive Therapy. Since the 1940s, it has become one of the most powerful tools available to psychiatrists. It has been tested in many different types of psychiatric illness and found effective especially in the treatment of the major psychoses. Because of its brutal nature and some of its side effects, including memory disturbances, ECT is used in a limited number of acute cases.

Another major breakthrough came in 1954 with the discovery of the antipsychotic effects of chlorpromazine. This drug brought relief to millions of psychotic individuals all over the world. This was a drug that could quiet excited, anxious patients and seemed to cure them. This discovery was followed by the introduction of numerous other drugs: sedatives, anti-anxiety agents, antidepressants, mood elevators, stimulants, etc. The list is quite impressive compared to the paucity of such agents only three decades ago.

In India most of these drugs are available. One problem with the use of drugs in the case of mental illness is that unlike in many other branches of medicine, where drugs work immediately or cure, many of these anti-psychotic drugs take a long time to effect change or are just symptom relievers. As a result there is a great likelihood that drug therapy will be discontinued by a patient after a while. Many of the drugs have side-effects (e.g. tardive dishenesia) that may cause the patients some discomfort. Another major reason for discontinuance is cost. The costs are both money and time. If the medication protocol has to be followed for a long time, the patient will require periodic check-ups at the clinic or hospital. Often with these centres located far from a patient's home these visits may become difficult to make and the drugs will therefore be discontinued.

The psychological methods or psychotherapies consists mainly of talking to the patients. This may happen either individually or in groups. Some of the varieties of psychotherapy that are practiced include: Psychoanalytic therapy, client centered therapy and rational emotive therapy. The most important prerequisite for any of these therapies is acceptance or motivation of the

client. Psychotherapies are used for all sorts of people, but seen to be most effective in the case of neurotics or mild psychotics.

Psychotherapeutic techniques are often imported from the West. They need to be somewhat modified to suit Indian conditions. According to Mahal[21] the Indian neurotic is distrustful of formal relationships and may well be disturbed by the exclusivity of traditional therapeutic relationships. This exclusivity may also disrupt the patient's family.

Behaviour therapy is based on the psychological principles of learning and conditioning theories. Its objective is to remove undesirable behaviours and to reinforce desirable behaviour therapy. The major drawback with behaviour therapy lies in the fact that only symptoms are treated. The individual is not necessarily treated as a whole. Behaviour therapy is relatively new in India and is only available in a few large centres.

Society-oriented varieties of therapy consist of therapies that modulate or manipulate the environment of the patient that may be noxious to his mental health. The significant environment varies from patient to patient-home, neighbourhood, and work place are three examples. At times the affecting environment may be too complex or large to manipulate. In this case a patient often relapses when returned to the environment that was believed to precipitate his illness.

Child guidance clinics are run specially to treat and help emotionally disturbed children. The most common etiological factors for emotional disturbances in children are the home, neighbourhood or school environment.

Family psychiatry is also a new field in India. It was pioneered by the late Dr Vidyasagar in Amritsar in the early 1960s. The family of a patient is treated as a whole in an effort to help the individual patient.

Occupational therapy is another vital part of modern rehabilitative therapy. Patients are trained in various crafts and trades to keep them physically and mentally occupied. This training also helps them feel like more productive members of the society. The training can assist in their recovery and in their re-adjustment to life after treatment.

Psychosurgery is another development in the treatment of psychiatric illness that has been introduced in the last thirty years. Here certain parts of the brain are removed or certain connections severed in an effort to restore a patient to a "normal" state. Initially this practice was received with enthusiasm, but the discovery of various after effects of surgery have lessened its popularity and use.

There are other forms of therapy that have been effective in the treatment of traditional psychological disorders as well as psychosomatic disorders. One of the most effective of these "therapies" is yoga. In India, according to Ikeoni and Fukuoko-Shi[22] , the Yoga Institutes of Santa Cruz in Bombay and Kaivalyadhama of Lonawala have reported, over the last fifty years, clinical effectiveness of yoga in treating many psychosomatic and psychiatric disorders. Improvement has been seen in anxious and "depersonalized" patients who were given Hatha yoga exercises once a week for a period of one year. We see that there are a number of varied approaches that can be used to alleviate or cure psychological disturbances that left untreated could cripple a society. Many of the treatments are not used because of poverty and illiteracy. In the next section we will examine the available resources in India for the practice of these therapies.

IV. Current Resources and Recommendations

Over the past forty years we have seen an increase in the number of people and institutions devoted to the care of the mentally ill in India. By 1960 they were over 100. A 1982 report by S Sharma[23] reports the current number at close to 1000. The number of psychologists is between four and five hundred according to Sharma. The number of psychiatric nurses is somewhere between three and four hundred.

In 1946 there were 13 mental hospitals. At present, Sharma[23] reports that there are 38 (34 under state control) hospitals with a total bed strength of approximately 25,000. These hospitals admit a total of 38,000 and 40,000 patients each year. In addition there are about 104 psychiatry units with inpatient and outpatient units serving almost 2 million patients a year. The bed strength of these units is about 3,000.

Although the facilities have grown in number over the past forty years, they are still unable to meet the ever growing demand. Even the low es-

timates of mental morbidity predict the number at about sixteen million. If the future brings increased stress and therefore increased morbidity,the available resources will prove to be less adequate.

The highest level at which the mental health of a country can be scrutinized and solutions can be posited is the Government. Hence, health planners at the national level ought to realize fully the importance of mental health for the individuals or the community, and for the nation The mental health objectives should be defined, taking into account the nature, extent, and consequences of mental disorders and the resources available, in order that reasonable plans are made. Decentralization of the mental health services and integration of these services with those for general health will serve the mental health needs of communities to the fullest. To this end mental health professionals ought to work together with experts in other fields (e.g. education, economics, social sciences and public health).

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Evaluation of Modern Technology

34. Health Care Technology and Quality Around the World

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I Background

The rapid diffusion of high technology procedures and equipment in health care has progressed largely uncontrolled. This development is characteristic of the paradigm of modern medical care: the medical model of health care celebrates scientific innovations and their applications in health care as improvements over conventional, regional or social practices in health and healing. International high-technology vendors, in conjunction with the scientific community,have introduced, manufactured, and legitimized the use of hi-tech medical equipment and related procedures globally, most often without prospective evaluation, quality assurance or comparison with existing technologies.

Even though high-technologies can be tools to promote health,the consequences of applying technologies inappropriately include health care cost escalation, unintended health outcomes,and social disapproval. Before or during the spread of technologies, it is essential that a comprehensive scientific evaluation is made, accounting for the various economic, social, and cultural variables found in specific health regions. Different areas may require different solutions.

Attempts to evaluate health technology and the quality of health care have been made in various areas of health at both international and national levels[1]. However, these attempts have usually been the result of individual, voluntary initiatives and therefore, disjointed and restricted to a particular health speciality, discipline, or selected diagnosis. In addition, an English literature review of all clinical trials studies performed in an ambulatory setting, during a 5 year period, revealed that none of the 73 studies examined included general health status as an outcome measure.[2]. Few studies included anything beyond physiological outcome measures.

It is thus extremely difficult for health care policymakers and practitioners operating on national or local levels to coordinate efforts and make the correct short or long-term decisions regarding appropriate selection of technologies, the acquisition of equipment and development of treatment standards. To ensure the appropriate use of individual technologies and their relevant contribution to the improvement in the quality of health care, scientific evaluation has become a necessity. Reliable assessments are even more important for developing countries. These countries could benefit by avoiding some of the social and economic mistakes that can be documented in the developed world with regard to health care technologies' efficacy, efficiency, cost and outcomes.

Prime examples are the unexpectedly large variations in many aspects of health care. Researchers and Government agencies have found wide variations in maternal mortality, length of hospital stay, referral rates, operation rates, use of antibiotics, complications of diagnostic procedures, and many other health utilization or status indicators. Differences in patient mix, demography, the severity of a disease and other such factors naturally explain some of these variations. However, since variations in the quality of care are likely, quality assurance is needed to reduce these variations and ultimately improve outcomes. For example, despite huge investments in health care (manpower, materials, education, medicines, etc.), the health indicators of many Western countries have not improved concomitantly. Quality assessment measures and intervention methodologies are both difficult and necessary as health care systems become increasingly complex and divergent.

II Recent Developments

In recent years the proliferation of new techniques and approaches has changed the charac-

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ter of health care remarkably and has affected everyone working in the field. The United States and the United Kingdom were some of the first countries to recognise the necessity for technology assessment in health care, and now technology-focused units are being established in various ministries of health and institutions of other countries as well[3].

Even though European health services have reached a relatively high standard of quality, there are still large differences between and within countries regarding the quality, effectiveness, and efficiency of health services. Quality assurance evaluations can attempt to reduce ineffective activities. Thus, both industrialized and developing countries need to monitor and coordinate the wide use of technologies and their impact on the quality of health services and health care delivery.

III WHO's European Programme on Quality of Care and Technologies (QCT)

WHO's global activities concerning the appropriateness of medical and health technology and quality assurance were developed at a relatively early stage. A overall programme with the aim of facilitating the introduction of newly developed health care technologies and evaluating the cost-effectiveness of existing technologies for the providers of care, health care institutions,and health policy-making boards, was initiated in 1980 in the European regions[4].

The Quality of Care and Technologies (QCT) Programme became active in 1982 (formerly named "Appropriate Health Care Technology"), and aims to promote quality assurance (QA) in health care technology assessment (TA). Appropriate assessments are based on scientific soundness, social acceptability, economic feasibility, appropriate use, and health outcome[5]. The QCT approach is action-research motivated.

The programme serves a clearinghouse on TA/QA information and is the focal point in WHO stressing the importance of TA/QA methodologies, policies, and training. This cross-section approach includes categorizing worldwide activities, analyzing literature reviews, assessing practical results, and integrating national and regional polices. By 1990, a comprehensive situational analysis of TA/QA activities will result from these inventories. QCT's ability to communicate information and promote the development of methods and mechanisms for TA/QA among interested parties will be enhanced by a resource database, WHO European library,WHO/University of Linkoping (LINFO) Directory, and journal publications[6].

Programme coordinators realize that the spectrum of TA/QA covers an ever increasing range of equipment and procedures, systems, devices and drugs. However, preliminary results and feedback from collaborators on specific TA/QA projects have produced exciting results: the assessment and subsequent selection of efficient and effective technologies that promote better health outcomes.

IV Barriers for Appropriate TA/QA

A key issue in QA is the relationship between quality and costs. One view maintains that QA itself costs money and may push the price of services higher; another view is that QA can contain costs by eliminating inappropriate services,and consequently reduce overall costs. A myth which TA/QA hopes to dispel is the belief that expensive procedures are always equivalent to high quality. This goal is particularly relevant as economic pressures to contain health care spending have underscored the need for the appropriate allocation of limited funds.

Other pressures lead to the inappropriate or premature use of equipment. The desire for prestige can distort ideas about the real usefulness and prudent application of scientific equipment: high-speed innovation can mean costly, early obsolescence. The media, like others, might be misinformed because detailed evidence of the value of certain equipment or procedures are unavailable. Consequently, hopes about new technologies can be raised by sensationalized case studies, and subsequently dashed by real applications.

Another barrier to unbaised assessment is the reliance on the medical or scientific model of health care. This model has almost completely neglected the social aspects of care, including interpersonal relations, patient well-being, and satisfaction. This narrowed approach has also limited QA evaluations in the past usually to whether scientific or technical criteria have been met during the process of care, rather than focusing on the outcome of care.

V Health for All Targets

WHO's QCT Programme complements its worldwide health for all strategy and its specific regional and global targets, relating to TA/QA[7]. These delineate that by the end of this decade each Member State document its TA needs; and by 1990, build overall mechanisms for QA of patient care within their health care system. These targets continue that by late 1990s, each Member State establish mechanisms for the systematic monitoring of health technologies, their effectiveness, efficiency, safety, acceptability, and cost.

These general goals are neither limited to equipment, devices,and drugs nor to the international policy arena. Clinical practice, health management and financing at all levels can benefit by the evaluation process. In addition, because the concept of quality incorporates both consumer and provider elements, a multi-sectored analysis is important as this method attempts to ensure provider, payer, and patient,involvement in the overall QA process.

VI Methodology

Dynamic involvement of all sectors of the community should help in TA/QA. Specifically, appropriate technology is defined as methods, systems, procedures, drugs,techniques and equipment that are scientifically valid, adapted to local needs, acceptable to those who use them and to those they are used on, and able to be maintained with resources the country or the community can afford[5]. New technologies should be selected from assessment based on their cost, suspected misuse, the availability of methods for assessment, widespread interest in the particular problem they address,the potential scope of their application, and the ability to obtain or access data for assessment.

QA denotes a spectrum of desirable characteristics of care: effectiveness, efficacy, efficiency, equity, acceptability, accessiblity, adequacy, and scientific/technical quality. These can be measured by health care outcome: reduction of death, disease, disability, and complications and aggravations of disease; the enhancement, maintenance and restoration of health; the ability of treated patients to participate in social and economic life; the alleviation of pain and discomfort; humane conditions of death in terminal illness; general well-being; satisfaction of patients and consumers with care; and reasonable costs.

Both TA/QA require active support. Creative information processing,financial incentives, evaluation policies,technology transfers, and appropriate laws, developed through intensive international and intra-organisational collaboration, are methods to achieve TA/QA. QCT not only attempts to facilitate this communication, but also uncovers areas where further research and development are required.

VII Research Protocols

WHO Member States and the QCT Programmer had early on defined a number of ares which should be given priority for developing TA/QA methodology.
The intention of QCT's approach is to provide health care policy makers and worker with the tools of self-evaluation and monitoring of TA/QA. It is vitally important to learn how the same health problems are solved in different ways within different cultures, all with their own medical systems and financial constraints. Application of the same protocols in different settings allows for fruitful comparison between individuals and regions[8].

However, research protocols require standards. International experts have agreed on the following common parameters: the technological aspect—accuracy, reproducibility, reliability; the diagnostic and/or therapeutic aspect — invasiveness, side effects, higher precision, time delay in obtaining results; the health outcome aspect—rate of cure, survival, recurrences, sequelae, complications; the economic aspect—total and partial cost of the disease, social cost,cost-benefit analysis; the socio-psychological aspect—patient/staff, cultural, and regional acceptance; and the appropriate application—defining the areas or countries where a given technology can be applied at a certain point in time. These parameters underscore the idea that the appropriateness of the technology will vary from one area to another and evolve over time.

VII Current activities

QCT on-going and recently initiated activities and research, exemplifying the TA/QA process, include the following:

(1) Communication Technologies

◦ Publication of "Appropriate Information Systems for Primary Health care-Guidelines for a

Computer Based System:" — a practical manual for obtaining and handling information at the Personal Computer (PC) level. Field trials started in Portugal and United Kingdom

- Collaboration with European Federation for Medical Informatics on information systems and technology assessment.
- Study testing the use of PCs for monitoring and self-evaluation in the area of maternal and child health care in a number of countries in Central Europe, South East Asia, Eastern Mediterranean, and Western Pacific regions.

(2) Hospital Infection Control

- Development of DANOP-DATA System software for the continuous surveillance, monitoring and self-evaluation of surgical wound infections. Software trial in 11 European countries; in use in China and Thailand.

(3) Variation in Health care

- Network for the study of variations of health care practices; establishment of the Copenhagen Collaborating centre for the Study of Regional Variations in Health Care.
- Study design on bacterial tonsillitis in order to determine the variations in diagnosis and therapy in relation to clinical outcomes and cost.

(4) TA for Medical Equipment

- International insulin pump study (Albania, France,Finland, German Democratic Republic, Hungary, Norway, Spain, United Kingdom, and Yugoslavia).

(5) Health Policy

- Analysis of equipment costs and formulation of quality indicators and targets on diabetes management, with the collaboration of the International Diabetes Federation.

(6) Use of Laboratory Procedures

- Development of criteria for utilization of laboratory tests; collaboration with European Committee for Clinical Laboratory Standards.

(7) Drug Use

- Evaluation of the consumption of antibiotics,particularly aminoglycosides and its influence on the occurance of multi-resistant bacteria (Austria, Czechoslovakia, Denmark, France, Federal Republic of Germany, Hungary, Italy, the Netherlands, Spain, Sweden, Thailand, and the United Kingdom) [9].
- Study of the effect of iron quantity in milk formulas on a child's growth and health in Hungary.
- Study of iron prophylaxis during pregnancy in Finland.

(8) Imaging Technologies

- Evaluation and promotion of the basic radiological system (BRS) in Albania, Denmark, Iceland, Hungary, Malta, Morocco, Norway, Portugal, Spain, the Union of Soviet Socialist Republics, and the United Kingdom.
- Production and distribution of a video-cassette on the "Rational Use of Radiodiagnostic Investigations," for the BRS.
- Evaluation of cost-efficiency of the BRA (Albania, Cyprus, Iceland, Israel, Jordan, Malta, Morocco, Portugal, Spain, Sweden, Tunisia, the United Kingdom, and Zimbabwe).
- Evaluation of the magnetic resonance imaging (MRI) as it influences diagnoses, therapies, health outcomes, economics, and patient acceptance.
- Future study on the clinical utilization of magnetic resonance spectrometry (MRS).
- Production and distribution of a video-cassette on the "Rational Use of Ultrasound in Diagnosis."

International Coordination. Many of the protocols and models designed by QCT and collaborators are being integrated in the TA/QA process. The programme relies heavily on promotion through international meetings as forums to discuss the objectives and methods outlined by WHO's QCT Programme. Appendix A contains a reference list of conferences either organized by WHO with QCT presentations or resulted from activities initiated by QCT.

IX Conclusion

Communication, education, and feedbacks are important aspects of the QCT programme. The necessity for a joint responsibility between WHO and interested parties is clearly demonstrated,as all of the activities described address global health problems. Research and protocol applications have been designed in such a way that all countries can join,poor and wealthy alike.

The ultimate objective of TA/QA is to improve health care in terms of outcome, functional abil-

ity, patient well being, consumer satisfaction and use of resources,by shaping health policy and practice. These goals require effective management and cooperation in order to implement activities at the institution , area, national, and international levels.*

Appendix A: CT Conference Reference List
Selected Meetings from 1988:

- "Evaluating Medical Practice: the case of Hysterectomy", in conjunction with the Copenhagen Collaborating Center and studies on regional variation, Jan. 1988.
- "Workshop on Appropriate Technology in Developing Countries," Marburg, Jan. 1988.
- "International Conference: The Hospital System: An Organizational Challenge for Italy in the '90s," Rome, March 1988.
- "WHO Health Strategies for Europe," Copenhagen, April 1988.
- "European Health Policy Forum (EHPF)—QA/TA Course," Brussels, June 1988.
- "EHPF—MRI Course," Brussels, June 1988.
- "Eighth African - European Congress of the International Society of Radiographers and Radiological Technicians," Helsinki, July 1988.
- "The Use and Misuse of Antibiotics Worldwide," focusing on antibiotic treatment for diarrhoea, urinary tract infections, respiratory tract infections and surgical prophylaxis, Freiburg, Oct. 1988.
- "Nordic Clinical Chemistry Project (NORDKEM)," focusing on quality assurance and appropriate utilisation in the field of laboratory technology, Copenhagen, Oct. 1988.
- "Role of Advanced Medical Technology in Hospitals and Health Services," Sofia, Oct. 1988.
- "Extracorporeal Shockwave Lithotripsy," focusing on future medical, technical, economic, and policy implications, Sweden, Nov. 1988.
- "EHPF—Adverse Drug Reaction Monitoring Systems," Brussels, Nov. 1988.
- "EHPF—Appropriate Technology for Primary Health Care," Brussels, Dec. 1988.
- "WHO Conference on Perinatal Technologies and Care," Melbourne,Dec. 1988
- "WHO Conference—Information Systems and Appropriate Technologies," Jaipur, Dec. 1988.

Future meetings:

- "DANOP-DATA System results," Copenhagen,April 1989.
- "Health Effect of MRI," Switzerland, Sept. 1989.
- "Quality Assurance and Laboratory Technology," Yugoslavia, Fall 1989.
- "WHO Drug Utilization Research Group,: the Netherlands, June 1989.
- "International Diabetes Federation Policy Meeting," St. Vincent, Oct. 1989.
- "Sixth World Conference on Medical Informatics— MEDINFO 89," Beijing, Oct. 1989
- "Appropriate Technologies and Quality for Services for Better Health," focusing on information systems, family health, policy, and technology, New Delhi, Feb. 1990.

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6. *Selected journals including past WHO/QCT publications: BIFATECH, European Newsletter on Quality Assurance,Health Affairs, International Journal of Technology Assessment, Infection, Clinica, European Journal of nuclear Medicine, Quality Review Bulletin, Health Policy and Regional Variation in Health Care.*
7. **Targets for Health for all 2000,** *WHO Strategy Publication,Copenhagen, 1985.*
8. **Towards an International Collaboration for Evaluating the Outcomes of Common Surgical Procedures,** *Copenhagen collaborating Centre for the Study of Regional Variations in Health Care.*
9. *K. Staehr Johansen, M. Storgaard, N. Cartensen et al.,"An International study on the Occurrence of Multiresistant Bacteria and Aminoglycoside Consumption Patterns,"* **Infection, 16***(1988)5: 313-322.*

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Here is a list of prominent manufacturers and suppliers of hospital and health care equipment. The list has been compiled from various sources. It is not exhaustive and does not include the companies and firms which we were not aware of, and also companies which did not respond to our enquiries.

We hope it would be useful to hospital and health administrators for effective decisions.

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I Cardiology and Intensive Care Unit Equipment

II X-Ray & Imaging Equipment

III General Hospital Equipment

IV Speciality and Superspeciality Equipment

V Gynaecology & Obstetric Equipment

VI Pathology & Laboratory Equipment

VII Anaesthetic and Related Equipment

VIII Medical Gases

IX Operation Theatre Equipment

X Dental Equipment

XI Surgical Equipment

XII Orthopaedic Equipment

XIV Aids for the Handicapped

XV Hospital Linen and Related Supplies

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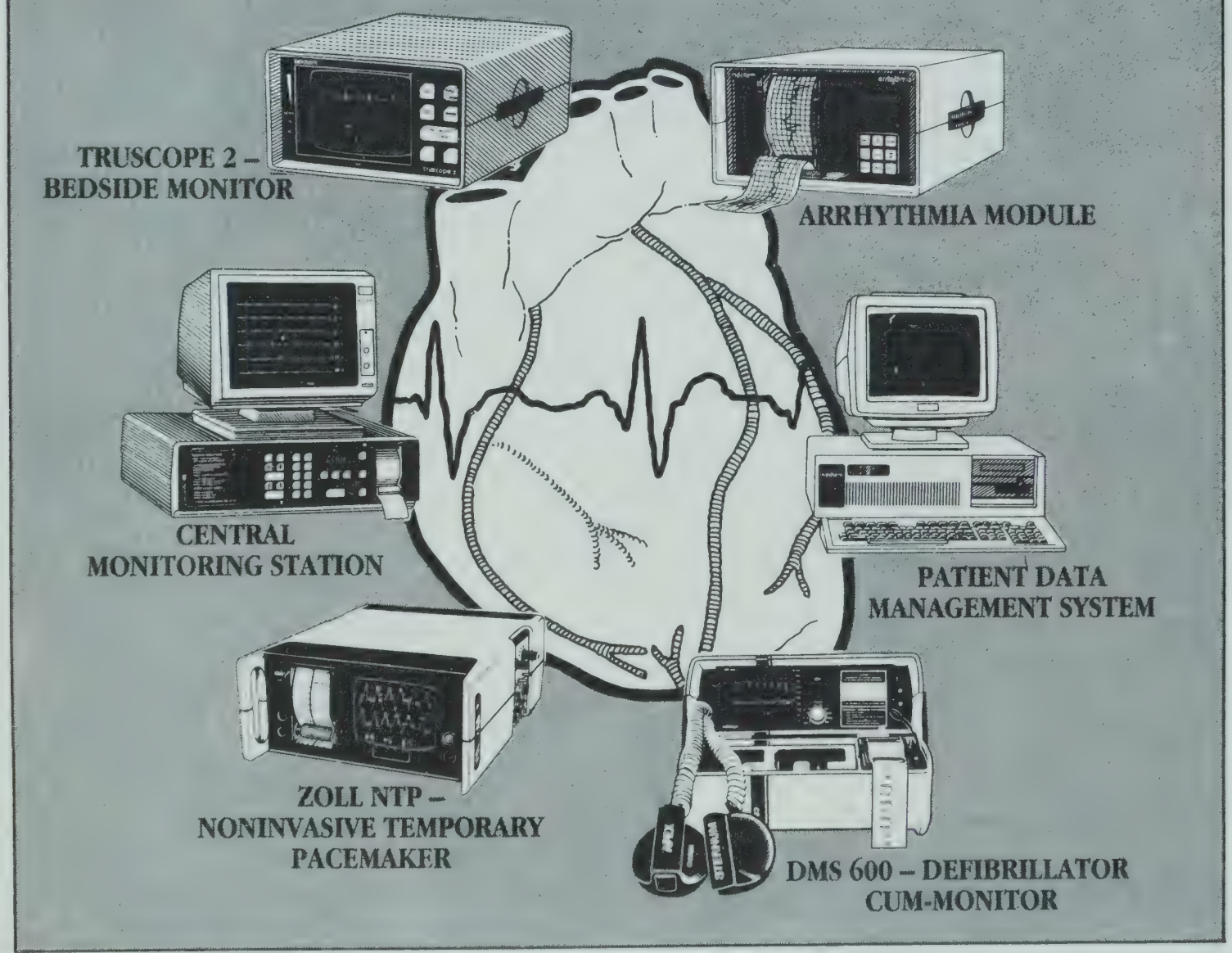

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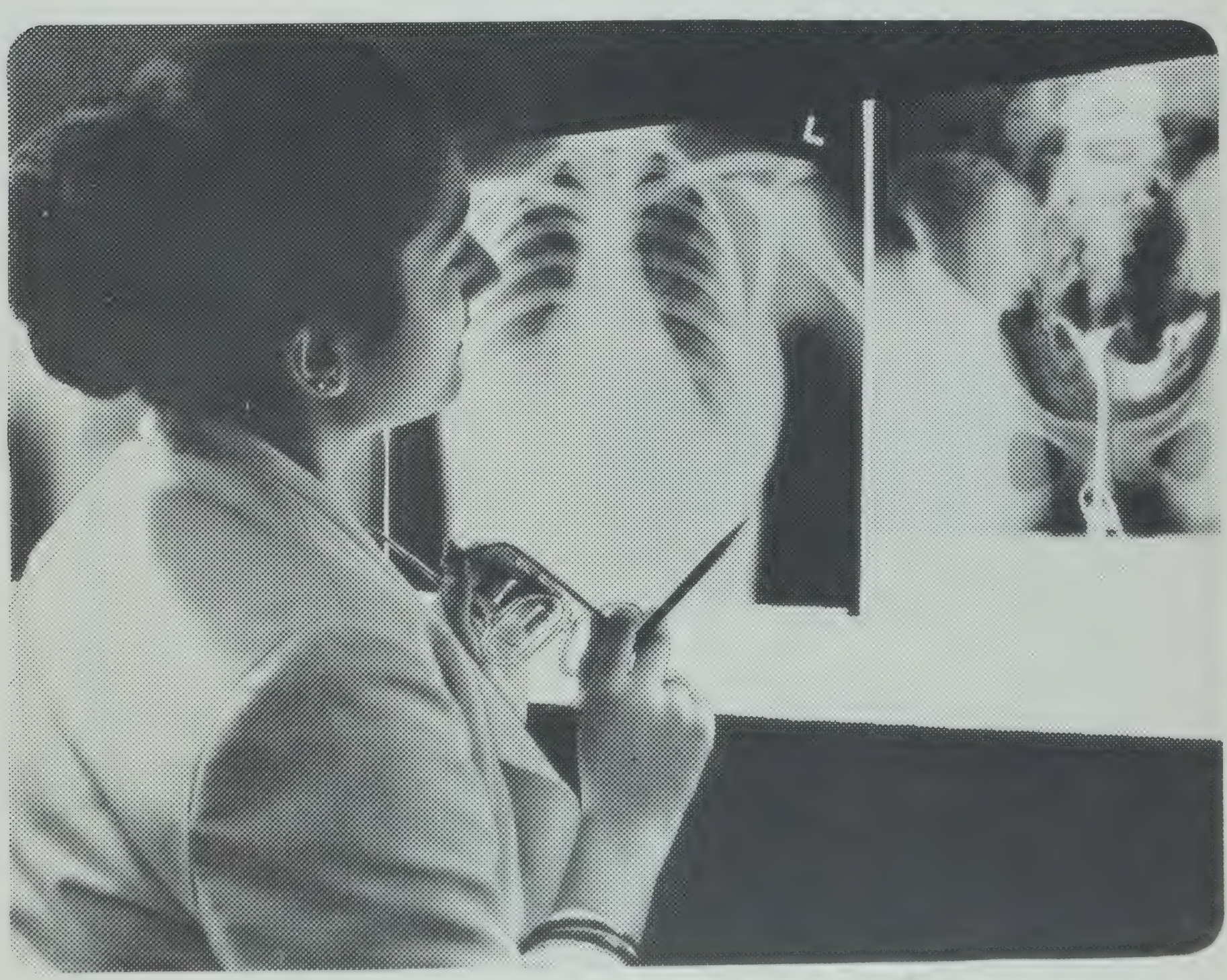

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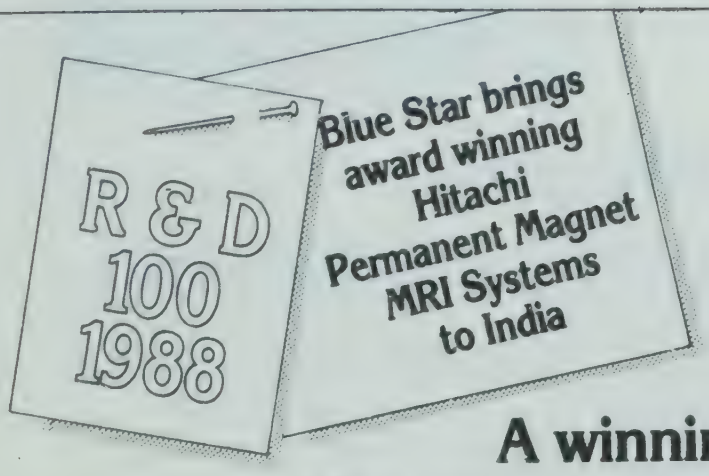

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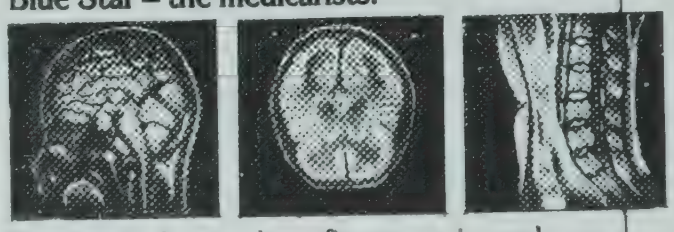

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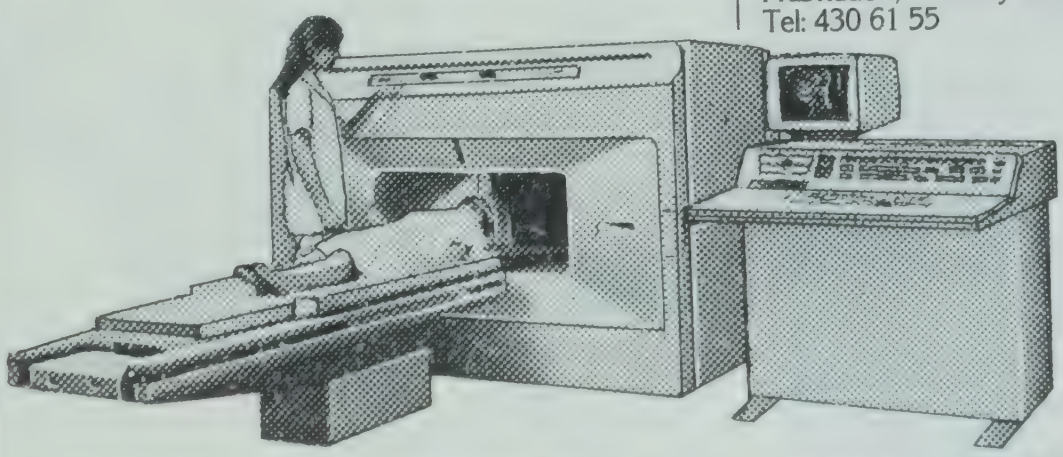

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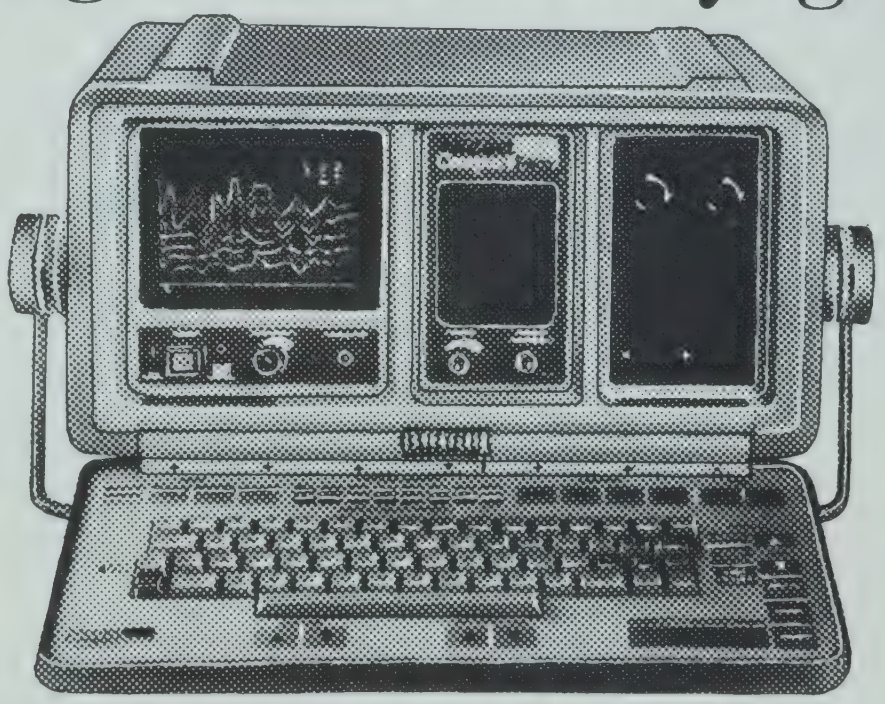

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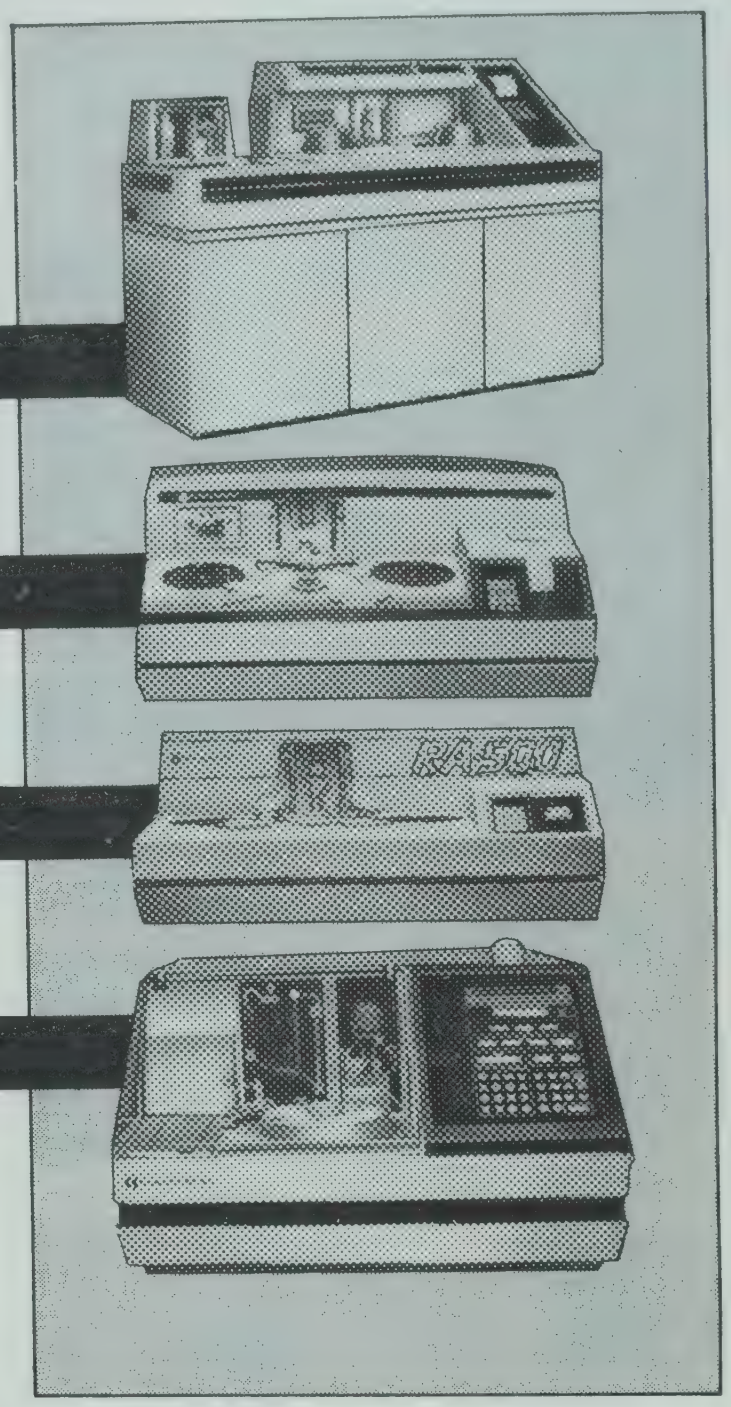

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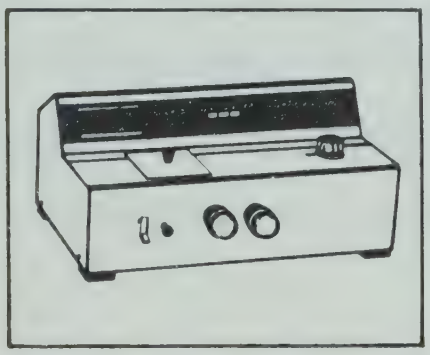

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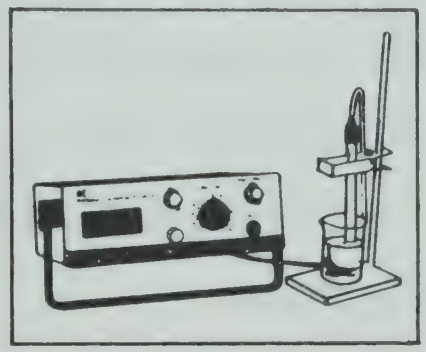

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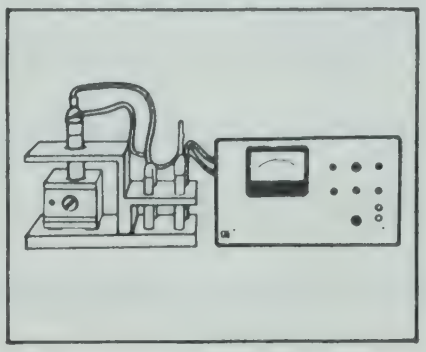

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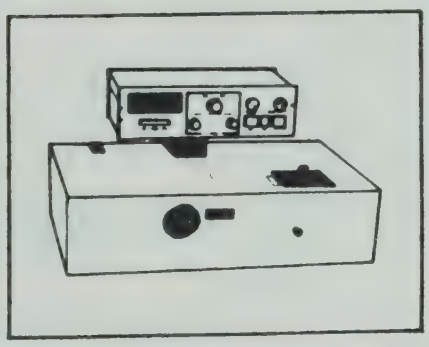

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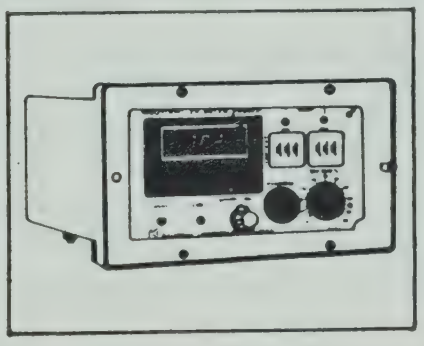

INDUSTRIAL (ON-LINE) PH METER PH5663

For accurate, on-line monitoring of pH of 0-14 pH. Accuracy 0.01 pH & dust proof enclosure.

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— 5°C to 50°C

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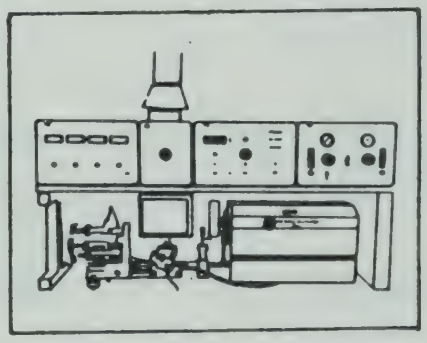

ATOMIC ABSORPTION SPECTROPHOTO METER AAS4127

Employs a high resolution single beam, grating monochromator optics. Micro Processor Interface for Signal Processing.

Features:

— Modular design on optical rail.

— Digital readout of absorbance, transmittance & concentration.

— Indigenous & imported Hollow Cathode Lamps for AAS.

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28. THE MODERN SCIENTIFIC INDUSTRIES, 199, Saket, Meerut - 250 001

29. SCIENTIFIC & SURGICAL CORPORATION, 71 Canning Street, III Floor, Begree market, P. Box - 444 Calcutta - 700 001

30. THE SCIENTIFIC INSTRUMENT CO. LTD, 6, Tej Bahadur Sapru Road, Allahabad - 211 001

31. SYSTRONICS, (Division of Ambalal Sarabhai Enterprises Ltd.) Wadi Wadi, Baroda - 390 007

32. UNIVERSAL BIOCHEMICALS, Enzyme House, Satya Sayee Nagar, Madurai - 625 003

33. YORK SCIENTIFIC INDUSTRIES, 1325 Hira Lal Building, Fasil Road, Ajmeri Gate, New Delhi - 110 006

34. W.J. ALCOCK & CO., (PVT) LTD, 7 K.S. Roy Road, Calcutta - 700 001

35. WESTERN LABORATORY SUPPLIERS, 43/18, Chakraberia Road, Calcutta - 700 020

VII Anaesthetic and Related Equipment

1. ALLIED SURGICALS & DRESSINGS, Post Box No. 1158, Bhagirath Palace, Chandni Chowk, New Delhi

2. ANAESTHETICS, 16, Vakharia Industrial Estate, Ram Mandir Road, Goregaon (West), Bombay - 400 104

3. BHARUCHA INSTRUMENTATION & CONTROL, 7 Camanagar, Mile 3/1, Nagar Road, P.O. Dunkirk Lines, Pune - 411 014

4. CARDIOTRACE ELECTRONICS, C-20 DSIDC Indl. Complex, Rohtak Road, Nangloi Delhi - 110 041

5. CENTURY INSTRUMENTS PVT. LTD, SCO 289(!st Floor) Sector 35-D, Chandigarh - 160 036

6. INDIAN OXYGEN LIMITED, P 43, Taratala Road, Calcutta - 700 088

7. INSTRUMENTS & MACHINES INC., 3 Arumuga Naichen Street, II Floor, Anna Road, Madras - 600 002

8. JAMBOTKAR ENTERPRISES, Grease House, 2 B, Jakeria Bunder Road, Sewree, Bombay - 400 015

9. J.N. MARSHALL PVT. LTD, Bombay-Pune Road, Kasarwadi, Pune - 411 034

10. KALEKAR SURGICAL INDUSTRIES, 305, Shamaldas Gandhi Marg, Bombay - 400 002

11. KODY MEDICAL ELECTRONICS PVT. LTD, P.O. Box 8596, Type II-37, Second phase, V.S.I. Estate Thiruvanmiyur, Madras - 600 041

12. MITRONICS, 9/10, Vakils Industrial Estate, Valbhat Road, Bombay - 400 063

13. SUR ELECTRICAL COMPANY PVT. LTD, P-29 C.I.T Road, Calcutta - 700 014

VIII Medical Gases

1. INDUSTRIAL ELECTRODES AND GAUGE LIMITED, 15, Ganesh Chandra Avenue, Calcutta - 700 013

2. SOUTHERN GAS LIMITED, Lovedale, Church Landing Road, Cochin - 682 016

3. DUDLE PILOT EQUIPMENT, 35, 11th Main, 12th Cross Malleswaram, Bangalore - 560 003

IX Operation Theatre Equipment

1. ASIAN SURGICAL CO., Nampally Station Road, Post Bag. No. 3, Hyderabad - 500 001

2. COGNATE INDIA, F-12, Mayapuri Industrial Area Phase II, New Delhi - 110 064

3. DELTA MEDICAL APPLIANCES, 108, Damaji Shamji Industrial Complex, Mahakali Caves Road, Chakala, Bombay - 400 093

4. FORBES FORBES CAMPBELL & CO.. LTD Forbes Building, Charanjit Rai Marg, Fort, Bombay - 400 001

5. INSTRUMENTS & MACHINES INC., 3 Arumuga Naichen Street, II Floor Anna Road, Madras - 600 002

6. HOSLAB, 27, New Empire Industrial Estate, J.B. Nagar, Bombay - 400 059

7. JAMBOTKAR ENTERPRISES, Grease House, 28, Jakeria Bunder Road, Sewree, Bombay - 400 015

8. JAY SURGICALS 32/A, Bhiwandiwala Building, Lakshamsi Napoo Road, Matunga, Bombay - 400 019

9. KALEKAR SURGICAL INDUSTRIES, 305, Shamaldas Gandhi Marg, Bombay - 400 002

10. KUMAR ELECTRONICS, Dhanwate Chambers, Sitabuldi, Nagpur

11. MAZDA MANUFACTURING CO., No. 6, Datta Mandir Road, Bhandup, Bombay - 400 078

12. MEDICAL CO-ORDINATORS PVT. LTD, 14 Wellingdon Estate, 24 Commander-in-Chief Road Madras - 600 105

13. MODERN PHARMA & SURGICAL CO., Bara Birwa, Alambagh, Lucknow - 226 005

14. PRECISION ELECTRONIC INSTRUMENTS & COMPONENTS, 17, Ranvir Building, 66/70 Princess Street, Bombay - 400 002

15. MSCO PRIVATE LIMITED, 301, Dr. E. Moses Road, Worli Naka, Bombay - 400 018

16. NEW DELHI INDUSTRIES, M-9, Lajpat Nagar-III, New Delhi-110 024

17. SAHNISONS PRIVATE LIMITED, 4/14-A, Asaf Ali Road, New Delhi-110 002

18. PHD ELECTRONICS, 204, Gurukrupa, Ram Gali, Opp. Balika Vidhyalay Kandivli (West), Bombay-400 067

19. X-RAY & ELECTROMEDICALS (INDIA), Malabar View, Chowpatty, Bombay-400 007

X Dental Equipment

1. ALLIED SURGICAL & DRESSINGS, Post Box No. 1158, Bhagirath Palace, Chandni Chowk, New Delhi.

2. AVCO DEN-MED SYSTEMS, 42,Pusa Raod, New Delhi - 110 005

3. COGNATE (INDIA), P-12, Mayapuri Industrial Area Phase, II, New Delhi-110 064

4. DENTAL PRODUCTS OF INDIA LIMITED, 25, Ashoka Chambers, BS Pusa Road, New Delhi-110 060

5. ELECTROMACK (INDIA). 3626, Darya Ganj, New Delhi - 110 002

6. ESSENTIAL DENTAL PRODUCTS, 39, Shahpur Jat, Opp. Asiad Village Gate, New Delhi - 110 016

7. MEDEX AGENCIES, 4852/24, Ansari Road Darya Ganj, New Delhi - 110 002

8. INDIAN DENTAL TRADERS. 3, Warden Court Gowalia Tank, Bombay - 400 025

9. SAHNISONS PRIVATE LIMITED. 4/14-A, Asaf Ali Road, New Delhi - 110 002

10. UB ELECTRONIC INSTRUMENTS LIMITED, 99, Gunrock Enclave, Secunderabad - 500 003

XI Surgical Equipment

1. ALLIED SURGICALS & DRESSINGS, Post Box No. 1158, Bhagirath Palace, Chandni Chowk, New Delhi.
2. ALPHA SURGICAL & ENGINEERING CO., 97, AB, Udyog Bhavan Old Prabhadevi Road, Bombay - 400 025
3. ALL INDIA SURGICAL MANUFACTURING CO., 146, Princess Street, Bombay - 400 002
4. ANDHRA SCIENTIFIC CO., LTD Janmabhoomi Chambers, Ballard Estate, Bombay - 400 003
5. APU IMPEX PRIVATE LIMITED. 114-B, Mittal Towers, Nariman Point, Bombay - 400 021
6. ASIAN SURGICAL CO., Nampally Station Road, Post Bag No.3, Hyderabad - 500 001
7. BHARAT ELECTRONICS LTD. ,(Andhra Scientific Company Unit) Rabindranath Tagore Road, Machilipatnam-521 001
8. BHATIA SURGICAL WORKS, 78, Govt. Industrial Estate, Bombay - 400 067
9. CAPITAL SURGICAL CO., PVT. LTD, 7, B.N.S Marg, Darya Ganj, New Delhi - 110 002
10. CALCUTTA METALLIC CO., 1, H Mukherjee Street, Calcutta - 700 025
11. DEO SURGICAL AND SCIENTIFIC CO., 95, Amersey Road, Bombay - 400 064
12. EXCON PIONEER INDUSTRIES, 5 and 6, Fancy Lane, 3rd Floor, Calcutta 700 001
13. GALTRON ELECTROMEDICAL INDUSTRIES, 118 Nahar & Seth Industrial Estate, Andheri (East), Bombay-400 093
14. FAIRDEAL SURGICAL CORPORATION, 106, Bank of Baroda Building, Palton Road, Bombay- 400 001
15. M/S. HOSPINS SURGICAL SYSTEMS, 31/8, Natesam Street, 1st Floor, Next to Siva Vishnu Temple, T.nagar, Madras - 600 017
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18. KEHR SURGICAL & ALLIED PRODUCTS PVT. LTD, C-34 Panki Indl Estate, Kanpur - 208 022

19. MADRAS SURGICAL EQUIPMENTS CO., 6, Ritchie St., Madras - 600 002

20. N K METAL WIRE FACTORY, Yamunanagar Road, Jagadhri - 3

21. NATIONAL SURGICAL INSTRUMENTS CO., 301, Haines Road, Worli, Bombay - 400 018

22. SAFEGUARD SURGICALS, Maninagar East, Ahmedabad - 380 008

23. SAHNISONS PRIVATE LIMITED, 4/14-A, Asaf Ali Road, New Delhi - 110 002

24. KALEKAR SURGICAL INDUSTRIES, 305, Shamaldas Gandhi Marg, Bombay- 400 002

25. SHAH MEDICAL & SURGICAL CO., LTD Ajwa Road, Vadodhara - 390 001

26. SOUTH INDIA SURGICAL CO., 196, Mount Road, Madras - 600 002

27. VOLTAS INTERNATIONAL LIMITED, 28-32, N.G.N. Vaidya Marg, Bombay - 400 023

29. VIJAYA SCIENTIFIC & SURGICAL CO., 16, Shreyas, 180, Backbay Recl, Bombay-400 020

29. WARDEN SURGICAL CO., PVT. LTD, Maplamahal, Thakurdwar Road, Bombay - 400 002

30. WESTERN INDIA SURGICAL CO., 98, S Gandhi Marg, Bombay - 400 002

31. X-RAY & ELECTROMEDICALS (INDIA), Malabar View, Chowpatty, Bombay - 400 007

32. ZENITH SURGICAL CO., 206, 3 C Mangaldas Building, Mangaldas Road, Bombay-400 002

XII Orthopaedic Equipment

1. ALLIED SURGICAL AND DRESSINGS , Post Box. No. 1158, Bhagirath Palace, Chandni Chowk, New Delhi

2. ASIAN SURGICAL CO., Nampally Station Road, Post Bag No.3, Hyderabad - 500 001

3. DELHI SURGICAL & DRESSINGS, Bhagirath Palace, Delhi - 110 006

4. H MUKERJI AND BANNERJEE SURGICAL PVT. LTD, 30/1, College Street, Calcutta - 700 012

5. INDIA MEDIKO INSTRUMENTS, 14, Angooribagh Market, Delhi - 110 006

6. INTERNATIONAL SURGICAL WORKS PVT. LTD, B-8, UD/3, Kartar Niwas, Jawaharnagar, Delhi - 110 007

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1. ALIDHARA ELECTRONIC INDUSTRIES, 2 Functional Estate, Extension Udyognagar, Udhna-394 210 Gujarat
2. ASSOCIATED ELECTRONIC ENGINEERS, 166, 7th Cross, Malleswaram, Bangalore-560 055
3. DELTA MEDICAL APPLIANCES, 108, Damaji Shamji Road, Industrial Complex Mahakali Caves Road, Chakala, BOMBAY-400 093
4. ELECTRO-BIOSONICS LTD, Near South Overbridge, Ernakulam, Cochin-682 016
5. ELECTRO MEDICAL APPARATUS CO., 3, Tandel Street, South Dongui, Bombay-400 009
6. GALTRON ELECTROMEDICAL INDUSTRIES, 118 Nahar & Seth Industrial Estate, Andheri (East), Bombay-400 093
7. HANSEL LABORATORY, 5-B,Russel Street, Calcutta-700 071
8. HITRA EQUIPMENTS, Khambate Lane Opp Victoria Garden Post,. Bombay 400 027
9. INDIA MEDICO INSTRUMENTS, 2-3, Gurwalon Ki Dharamshala, Angoori Bagh New Delhi-110 006
10. M/s. INOR, INDIAN INSTRUMENT ORTHOPAEDIC, 209, AZ Industrial Estate, G Kadam Marg, Lower Park, Bombay 400 013
11. JAY SURGICALS, 32/A Bhiwandiwala Bldg. L.N. Road Matunga, Bombay-400 019
12. JOHARI ELECTRO-TECH COMPANY, 28, Nehru Park, Jodhpur-342 003
13. KODY MEDICAL ELECTRONICS LTD, 2, 12th East Street, Kamaraj Nagar, Madras-600 041
14. MEDICAL & INDUSTRIAL ELECTRONICS, 24,17th Cross, Malleswaram, Bangalore-560 055
15. MEDICAL ELECTRONIC INDUSTRIES, 97 Napean Sea Road, III Chandralok 'A' Ground Floor, Bombay-430 006
16. MEDICANICS, 10 Seventh Cross Street,Indira Nagar, Adyar, Madras-600 020
17. PLA ELECTRO APPLIANCES PVT. LTD, Thakor Estate, Kurla Kirol Road, Vidyavihar (W), Bombay-400 086
18. X-RAY & ELECTROMEDICALS (INDIA), Malabar View, Chowpatty, Bombay-400 007

XIV Aids for the Handicapped

1. ARPHI INCORPORATED, Prabhadevi Industrial Estate, Veer Sarvarkar Marg, Bombay-400 025
2. ARTIFICIAL LIMBS MANUFACTURING CORPORATION OF INDIA, (ALIMCO) Grand Trunk Road, Kanpur-208 016
3. ELCON PVT. LTD, 1203, Prasad Chambers Opera House, Bombay-400 004
4. ELECTRO-TECH CORPORATION, 53 Sector 9,Chandigarh-160 009
5. HEARING AID CENTRE, Kailash Cinema Chowk, Civil Lines, Ludhiana
6. INDIA MEDICO INSTRUMENTS, 2-3 Gurwalon Ki Dharamshala, Angoori Bagh, New Delhi-110 006
7. MICRO MEGA ELECTRONICS, 10 A Madan Tolla Street, Calcutta-700 005
8. PERFECT ELECTRONIC (INDIA), 171-E Kamla Nagar, Delhi - 110 007

9. PRADIP ELECTRONICS, Jay Krishna Road, Patna - 800 009

10. PHILIPS, Peico Electronics & Electricals Ltd., Band Box Building, 254-D, Dr. Annie Besant Road, Bombay - 400 025

11. SONIK AIDS, 52, 7th Cross Road, S.P. Extn. Bangalore - 560 003

12. VOLTAS INTERNATIONAL LIMITED, 28-32, G N Vaidya Marg, Bombay - 400 023

XV Hospital Linen and Related Supplies

1. ALLIED SURGICALS & DRESSINGS, Post Box No. 1158, Bhagirath Palace, Chandni Chowk, New Delhi

2. ASSOCIATED RUBBER INDUSTRIES PVT. LTD, Union Bank Building, B S Marg, Bombay 400 023

3. BHATIA SURGICAL WORKS, 78, Govt. Industrial Estate, Bombay - 400 067

4. BOMBAY SURGICAL CO., Opp. H N Hospital, Sandhurst Road, Bombay 400 004

5. BRISK SURGICAL COTTON, 138, Gandhi Chowk, Thane 1

6. M/S CURADIA, RANBAXY DIVISION, 5-4-187/6, Karbala Maidan, M.G. Road, Secunderabad.

7. DIAMOND SURGICAL DRESSING WORKS, 381, S Guruji Marg, Bombay - 400 011

8. JOHNSON & JOHNSON LTD, Spencers Building, 30, Forjett Street, Bombay - 400 036

9. KEHR SURGICAL & ALLIED PRODUCTS PVT. LTD. C-34 Panki Indl Estate, Kanpur - 208 022

10. INDUSTRIAL PRODUCT PROMOTION & MARKETING SERVICES, 188, Commercial Complex - I, Jhandewalan Extension, New Delhi - 110 055

11. LEUKOPLAST (INDIA) PVT. LTD, Eucharistic Congress Bldg III, 4th Floor 5, Convent St. Bombay - 400 039

12. MADRAS SURGICAL EQUIPMENTS CO., 6, Ritchie St. Madras - 600 002.

13. SAFEGAURD SURGICALS, Maninagar East, Ahmedabad - 380 008

14. PANKAJAVALE PRODUCTS, 96-1/15, North street, Chatrapatti, Tamil Nadu - 626 102

15. PHARMA SURGICALS, Z 16 School Lane, Babar Road, New Delhi - 110 001

16. STANDARD SURGICAL & DRESSING WORKS, 28-B, Genu, Bombay 400 002

17. SUDHIR SURGICAL CO., 46, Old Hanuman Lane, Bombay 400 002

18. SUPREME SURGICAL CO., 3057 Hardhyan Singh, Karolbagh, New Delhi 110 005

XVI Cold Chain & Refrigeration Equipment

1. BATLIBOI AND COMPANY LTD., Apeejay House, Dr. V.B. Gandhi Marg, Fort, Bombay-400 001

2. BLUE STAR, Blue Star House, 13, Kodambakkam High Road, Madras- 600 034

3. GODREJ & BOYCE MFG.CO.PVT.LTD, Godrej Bhavan, Hume Street, Bombay-400 001

4. HYDERABAD ALLWYN LIMITED, Allwyn Bhavan, Erragadda, Hyderabad-500 018

5. KELVINATOR (INDIA) LTD, Atma Ram House, 7th Floor, I Tolstoy Marg, New Delhi-110 001

6. GEM INDIA LIMITED, P-2, Connaught Circus, New Delhi 110 001

7. V. KRISHNA & CO., Motibaug, V.N. Purav Marg, Chembur, Bombay-400 071

8. VOLTAS LIMITED, Appliances Division, 19, J.N. Heredia Marg, Ballard Estate, Bombay-400 038

XVII Computers for Health Care-Hardware & Software Manufacturers

1. APPLIED COMPUTER SCIENCES ORGANIZATION, 316, Chandralok Complex, Sarojini Devi Road, Secunderabad - 500 003

2. BLUE STAR LIMITED, 74, SDF III, SEEPZ, Andheri (E), Bombay - 400 096

3. CALCOM ELECTRONICS, B-23, Wazirpur Industrial Area, Delhi -110 052

4. COMPUTER MAINTENANCE CORPORATION (CMC) LTD., 1A, Ring Road, New Delhi - 110 014

5. CHENAB INFORMATION TECHNOLOGIES PVT. LTD, J-1A, Ansa Industrial Estate, Saki Vihar Road, Saki Naka, Bombay - 400 072

6. CHIPS AND BITS, MSS Building, Cheroty Road, Calicut, Kerala.

7. COMPUTER AND INFORMATION SYSTEMS PRIVATE LTD., Kotahwala Market, Tripolia Bazar, Jaipur - 302 002

8. CRYSTAL GRAPHICS AND SOFTWARE, 771, Bhandarkar Road, Pune - 411 004.

9. DCM DATA PRODUCTS, Vikrant Tower, 4, Rajendra Place, New Delhi - 110 008

10. DREAM COMPUTERS, M-13, Greater Kailash II, New Delhi - 110 048

11. EIKO COMPUTERS PRIVATE LIMITED, 10/5 Lakshminarayan Complex, 5th Floor, Palace Road, Vasanthnagar Bangalore - 560 052

12. ELECTRONIC CORPORATION OF INDIA LIMITED, ECIL Post Office, Hyderabad - 500 762

13. ELECTRONIC SYSTEMS PUNJAB LIMITED, B-81, Phase VII, Industrial Area, SAS Nagar, Chandigarh - 160 055

14. ESSEN COMPUTERS, A-7 GIDC, Electronics Complex, Sector 15, Gandhinagar - 382 015

15. ECONOTECH SERVICES PRIVATE LIMTIED, SS Management Services Private Limited B-310 & 311, Somdatt Chambers, 5, Bhikaji Cama Place, New Delhi - 110 066

16. HINDITRON, 504, Raheja Chambers, Nariman Point, Bombay - 400 021

17. HCL LIMITED, Sector III, A-10, Noida - 201 301 U.P

18. INDCHEM ELECTRONICS, K R Building, 124-A Lattice Bridge Road, Adyar, Madras - 600 020

19. INFOTON SYSTEMS AND SERVICES (P) LIMITED, 160, Shivshakti Industrial Estate, Off Andheri Kurla Road, Andheri (E), Bombay - 400 059

20. INFOSYS CONSULTANCY PRIVATE LIMITED, Borland Division, Infosys House, 7th Main, 5th Block, Jayanagar, Bangalore - 560 041

21. INTEGRA MICRO SYSTEMS PRIVATE LIMTIED, 9, KHBCS Layout, West of Chord Road, Bangalore - 560 079

22. INTERNATIONAL COMPUTERS INDIAN MANUFACTURE, Narottam Morarji Marg, P.O.Box 516, Bombay - 400 001

23. INTERNATIONAL DATA MANAGEMENT, Safed Pool, Kurla, Bombay - 400 072

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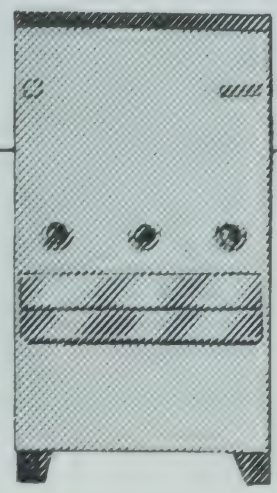

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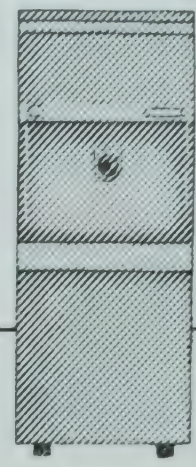

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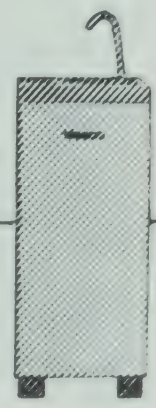

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4. ATLAS SURGICAL COMPANY, 332, Lajpat Rai Market, New Delhi- 110 006

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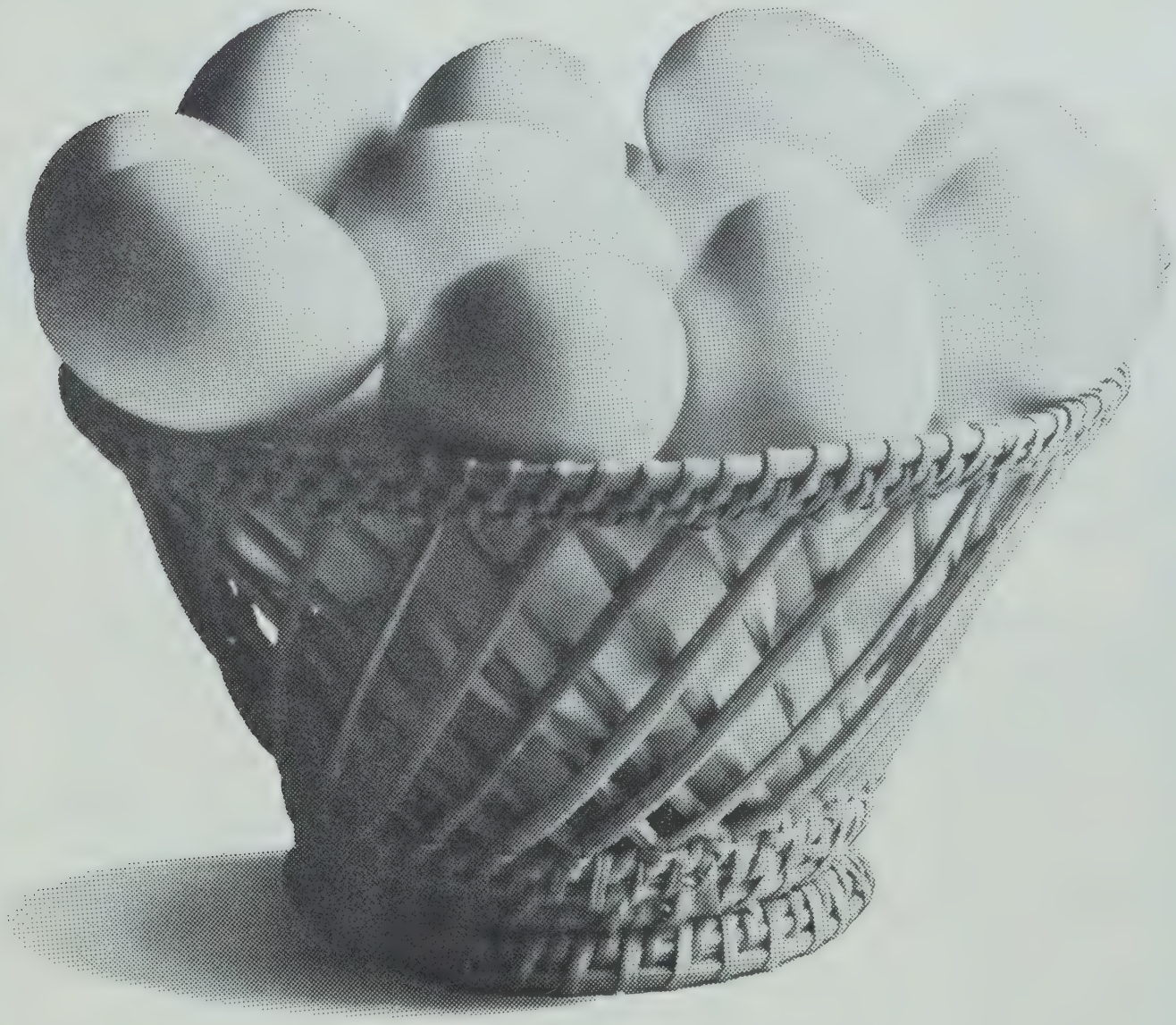

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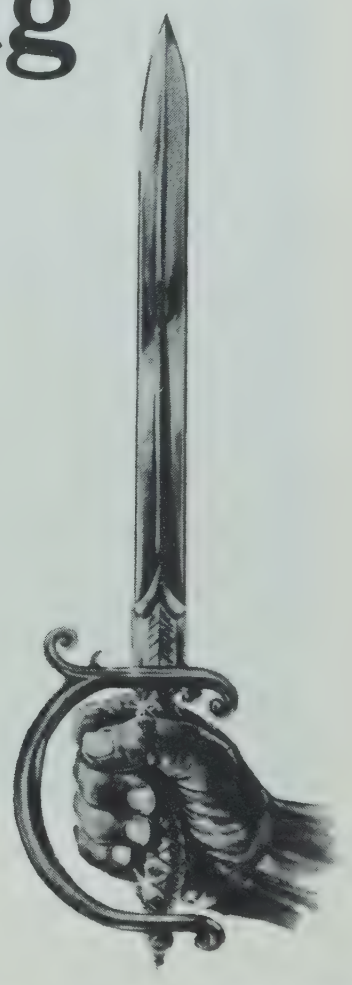

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16. NATIONAL SCIENTIFIC PRODUCTS, 4th Line, Sambasivapet, Guntur 522 001, Andhra Pradesh.

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1. ATUL DRUG HOUSE, 85-Dr Annie Besant Road, Worli - P.B.NO. 6573, Bombay - 400 018

2. ABBOT LABORATORIES INDIA LIMITED, Jahangir Building, 133-Mahatma Gandhi Road, P.B. NO. 133 Bombay - 400 023

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4. COMFORTAIRE IMEX (P) LTD, 187, Mahatma Gandhi Road, Secunderabad-500 003

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7. EAGLE SURGICAL DRESSING MFG CO., 202, Lajpat Rai Market, Chandni Chowk, Delhi -110 006

8. ELECTRONIC ENGINEERING CORPORATION, Medical System Division, T-4, Dr Vikram Sarabhai Instronics Estate, Madras-600 041

9. ELECTRONICS LIMITED, Atmaram House, 1, Tolstoy Marg, New Delhi-110 001

10. EUREKA FORBES LIMITED, Farah Commercial Complex, 68, J.C.Road, Bangalore - 560 002

11. GALTRON ELECTROMEDICAL INDUSTRIES, 118, Nahar & Seth Industrial Estate, Andheri (East), Bombay 400 093

12. HANSEL ELECTRONICS INDUSTRIES, 58, Russel Street, Calcutta-700 071

13. JAINSONS ENGINEERING & ELECTRONICS, P.O.Box,5245, 175 Samuel Street, 2nd Floor, Bombay-400 009

14. LOGIC CONTROLS PRIVATE LIMITED, Hemkunt Tower, 16th Floor, 98 Nehru Place, New Delhi-110 019

15. MASER ELECTRONICS PRIVATE LIMITED, 76, Vishal Industrial Estate, Bhandup, Bombay-400 078

16. MODERN BALANCE WORKS, D 54/19 Aurangabad, Varanasi, UP. - 221 010

17. OZR ELECTRO TECHNICS PRIVATE LIMITED, B-82, Road, A, Cooperative Industrial Estate, Satpur, Nasik 422 007 Maharashtra.

18. SHAKTI ELECTRICALS PVT.LTD, C-20, Industrial Estate, Jaipur-302 006

19. SPARK ENGINEERING COMPANY, 152, 4th Main Road, Chamarajpet, Bangalore-560 018

20. SPENCER & COMPANY LIMITED, 769, Anna Salai, Madras-600 002

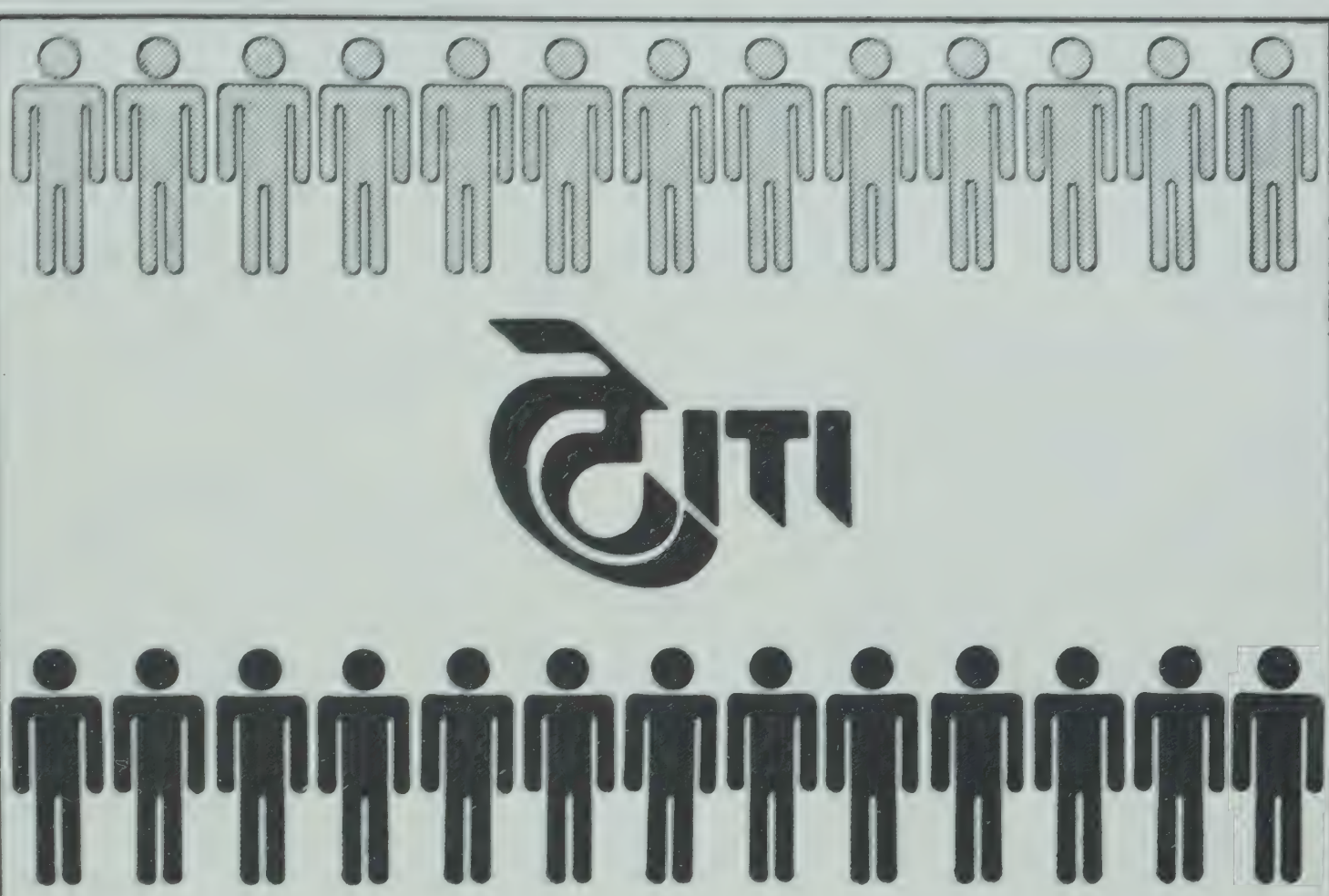
21. THERMAX PRIVATE LIMITED, Chinchwad, Pune-411 019

22. UNITEK, Pazhanganad, Kizhakkambalam, Alwaye, Kerala-683 562

XXIV Hospital Communication Systems

1. BPL INDIA, 32, Church Street, Bangalore - 560 001

2. COPPER CONNECTIONS, 5-375, Greater Kailash-1, New Delhi-110 048



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7. MICRO MEGA ELECTRONICS, 10A Madan Tolla Street, Calcutta - 700 006
8. MODEX ASSOCIATES, 3-6-478/A&B, First Floor, Himayatnagar, Hyderabad-500 029
9. PEARL ELECTRONICS GROUP, 108, Siddharth, 96 Nehru Place, New Delhi-110 019
10. PRODUCT PROMOTERS, P.O.Box.3577, New Delhi-110 024
11. SILVER AGENCIES, 129 Satguru Complex, First Floor, 5-9-30/21-30A, Bashirbagh,Hyderabad-500 029
12. SUNEEL COMMUNICATIONS LIMITED, 301/6, Kaushalaya Park (East), Haus Khas, NEW DELHI - 110 016
13. SUPER ELECTRONICS, Rustom Building, 29 V.N.Road, Fort, Bombay-400 023
14. SUPERPHONE INDIA PVT LTD, 100, Government Industrial Estate,Charkop, Kandivli(West), Bombay-400 067
15. SWEDE (INDIA)TELTRONICS LIMITED, Almas Centre, IV Floor, 87 M.G.Road, Bangalore-560 001
16. TELELOCK ELECTRONICS, Chandabhai Building, Mangaldas Road, Bombay - 400 002
17. UPTRON ,10, Ashok Marg, Lucknow - 226 001
18. USHA ELECTRONICS, First Floor, Plaza Cinema, Connaught Place, New Delhi - 110 001

XXV Security Systems

1. ABHITRON INDIA, 386, F/39, Mandodari Building, New Badam Wadi, Lamington Road, Girgaum, Bombay - 400 004
2. ELECTRONIC SERVICES, D/21, Commerce Centre, Tardeo Main Road, Bombay - 400 034
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6. NEW FIRE ENGINEERS PRIVATE LIMITED, 16, Industrial Estate S.K. Ahire Marg Worli, Bombay - 400 025
7. RAMATRONICS, BLP Road, Sahibgunj - 816 109

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1. BATLIBOI AND CO., PVT. LTD, Apeejay House, Samachar Marg, Bombay - 400 001.
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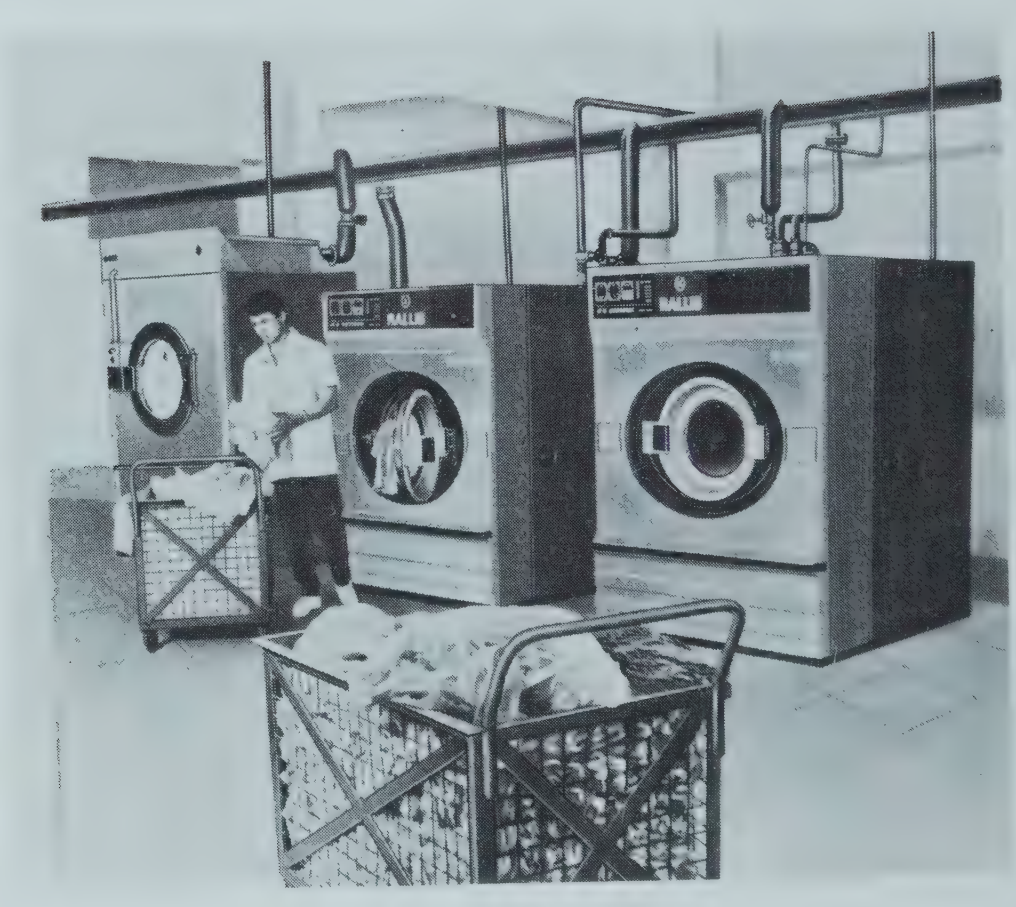
3. RALLIS INDIA LIMITED, United India Life Bldg., F Block, 2nd Floor, Connaught Place, New Delhi - 110 001

XXVII Kitchen Equipment

1. FARNAZ APPLIANCES, 19-21 Apurva Industrial Estate, Makwana Road, Andheri East, Bombay - 400 059
2. HALDER & COMPANY, 188/2, A, Rai Bahadur Road, Calcutta - 700 053



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Economical, hygienic, fully automatic Washer-Extractor

Rallis India Ltd. in collaboration with Inamoto of Japan, have recently introduced a computerised industrial washing machine. Ralli Compuwash.

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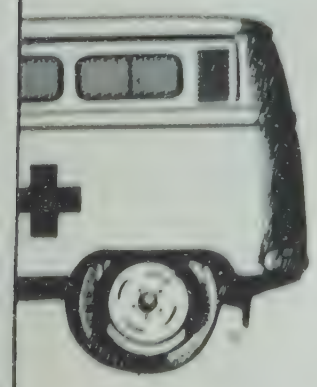

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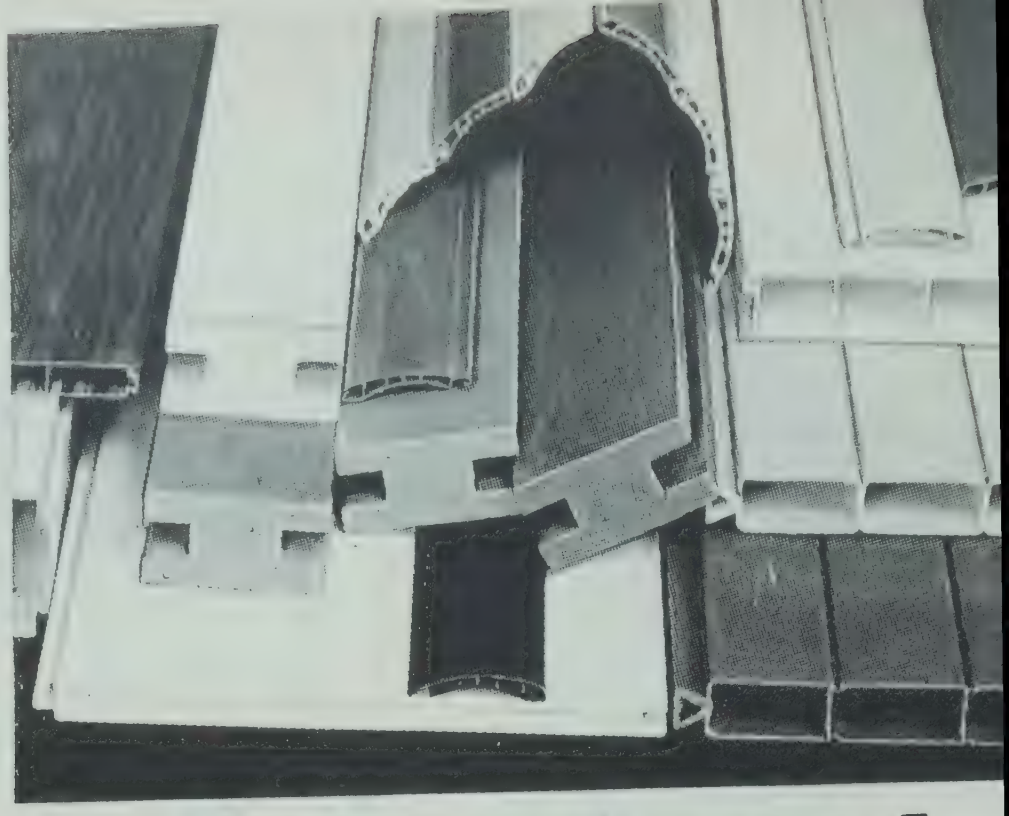

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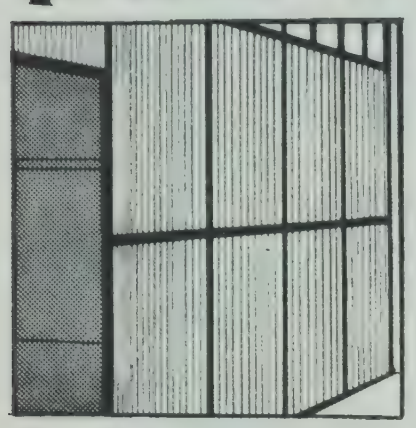

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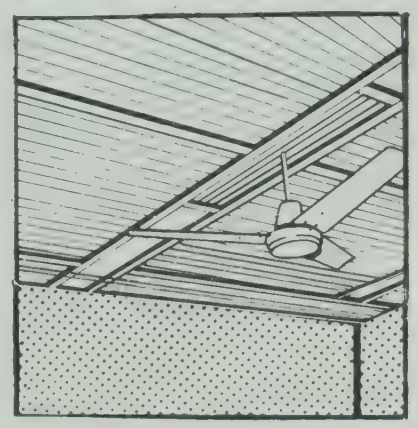

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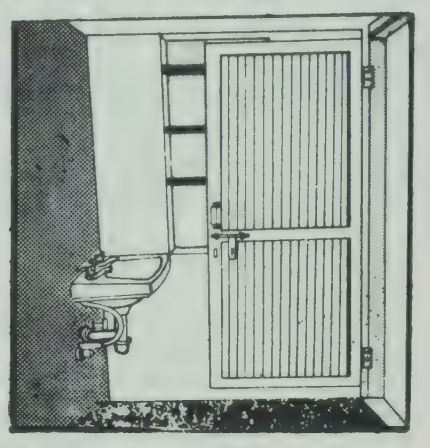

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Indian Society of Health Administrators (ISHA), Bangalore is a premier society of medical and non-medical professionals, established in 1979 to bridge the gap between the actual and desirable state of health services in India through professional development of health personnel. It has 25 Regional Offices, large membership of individuals and institutions; organises annual conferences; training programmes at national, state and institutional levels; engages in research leading to policy formulation and effective programme management; provides consultancy services to national and international organizations, and Central and State Governments; publishes the Journal "Health Administrator" and guidebooks and reports to professionalise health systems and contribute towards professional development of health personnel. Plans are under way to start a full-time Post-Graduate programme and correspondence programme in "Health and Hospital Administration".

Recent decades have seen an explosive growth and introduction of modern technology in hospital and health care. Quite apart from the technology involved in research and formulation of newer drugs, the advances in diagnostic and therapeutic technologies, today, require far more complex decision-making by physicians and hospital and health administrators - the decision could be, whether to request for a test on a patient or not, whether to buy an equipment or not, and even whether to modernize a hospital or not.

The complexity of decision-making stems from several factors. Some of these are: newer diagnostic modalities (e.g. Magnetic Resonance Imaging) being introduced claiming a quantum jump in diagnostic-therapeutic capabilities; newer and newer modifications of pre-existing models; high capital costs of these equipments (in some cases running into crores of rupees); availability of scanty information on the useful and viable applications; and even scantier information about their impact on the overall patient outcomes. These factors are further compounded by aggressive marketing by the manufacturers.

In this situation, it is extremely important to be update on the basic principles of the technology, medical applications, additional benefits to be gained by acquiring the equipment, and most important, the impact it would make on patient outcome. This first edition of the ISHA Sourcebook covers a whole range of specialities, from cardiology and medical imaging to, computers in hospital and health care management. The Book seeks to update the health professionals on the perspectives and applications of various modern technological devices in the respective medical fields. It also presents carefully selected articles reviewing the utility, experience and limitations felt with certain major technologies.

While attempting to bridge the information gap, we have also attempted in this Book, to serve the needs of specialists and general practitioners who would like to be update on recent technological advances, not only in their own speciality but also in other specialities. This is vital not only for academic interest but also to make a rational decision, whether for intelligent referral of a patient for investigation and treatment, or for scientific management of hospital and health care.

Of course, for hospital and health administrators, the Book would also greatly aid in avoiding costly mistakes, which would result in maximal utilization of existing scarce resources, and minimize misuse of equipment and unethical practices.